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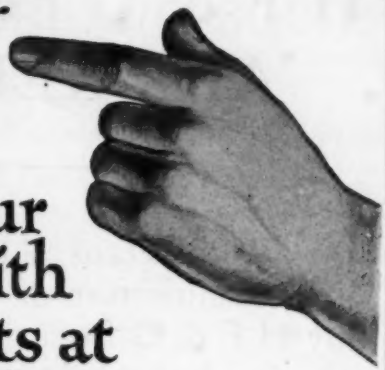

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ORIGINAL PAPERS

THE MICROSTRUCTURE OF EARTHENWARE[1]

By Herbert Insley

ABSTRACT

Nineteen samples of glazed earthenware bodies were examined with the petrographic microscope to study the development of mullite ($3Al_2O_3 \cdot 2SiO_2$) within the body and at the glaze-body contact of the different samples. A correspondence of the development of mullite within the body and at the contact of glaze and body was observed and there seemed to be a relation between the firing temperature of the body and the size of mullite needles formed. Seventeen photomicrographs are shown.

In the course of a study of the causes of crazing of glaze on a type of earthenware generally known as "semivitreous" china, which was carried on coöperatively by the Bureau of Standards and the United States Potters Association, petrographic-microscopic examinations and photomicrographs were made of a number of sections of glazed plates to determine the effect of glazing and of heat treatment on the structure within the body and at the contact of body and glaze. While the con-

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[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Glass Division.) Received February 28, 1927.

NOTE.—The writer wishes to thank A. V. Bleininger and also V. J. Roehm, at one time a research associate at the Bureau of Standards for the United States Potters Association, for the data on the heat treatments and the absorption of the bodies examined.

clusions drawn from the relations of the microstructure of the ware to the firing conditions, composition, etc., are tentative and may need revision, the results of the microscopic examination and the photomicrographs themselves are of sufficient interest to justify their publication.

The specimens examined were thin sections[1] prepared from pieces which had been cut or broken from 5-inch plates. The unglazed plates were fired in the glost kilns by the potteries which furnished the bodies. No data as to the temperature of this fire at the potteries are available, but it is understood that most potteries fire their glost kilns to cones 4 to 5. After the receipt of the bisque plates at the Bureau, one-fourth of the plates from each pottery were glazed as received, one-fourth fired in the bisque to cone 6 and held for 8 hours at the temperature at which cone 6 went down, one-fourth fired in the bisque to cone 8 and held for 6 hours at the temperature at which cone 8 went down, and one-fourth fired to cone 10 and held for 4 hours at the temperature at which cone 10 went down. Cones placed inside the saggers showed in general cone 8 one-half down for the cone 6 firing, cone 9 one-half down for the cone 8 firing, and from cone 11 one-half down to cone 12 down for the cone 10 firing. Each specimen was glazed with the glaze used at the plant from which the body was procured. All the glost firing was done at the Bureau of Standards, firing cone 5 down.

In Table I the samples are designated by number and letter. The number indicates the manufacturer and all specimens designated by the same numbers have the same glaze composition and are supposed to have the same body composition. The letter following the number indicates the heat treatment of that sample previous to glazing.

Microscopic observations were generally made with an objective of 4 millimeters focal length and an eyepiece of 12.5 magnification, giving a total magnification of about 560 diameters. Photomicrographs were taken with an objective of 4 millimeters focal length, an eyepiece of 15 magnifications and the necessary camera-bellows extension to give a magnification of 600 diameters. The illuminating source was a carbon arc light used with a Wratten B (green) filter.

The firing of feldspar-quartz-clay mixtures to high temperatures (above 1200°C) results in the melting of the feldspar, the formation of minute mullite[2] crystals within the clay grains and the partial solu-

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[1] The sections were made by W. H. Tomlinson, Swarthmore, Pa.

[2] Mullite is the compound $3Al_2O_3 \cdot 2SiO_2$, which is formed in clay bodies at high temperatures. (Bowen and Greig, *Jour. Amer. Ceram. Soc.*, **7**[4], 238–54 (1924), and Bowen, Greig, and Zies, *Jour. Wash. Acad. Sci.*, **14**, 183–91 (1924). Formerly this compound was thought to be sillimanite with the composition $Al_2O_3 \cdot SiO_2$.

tion of the quartz grains. Klein[1] has shown that the firing temperature is the most important factor in the development of the mullite needles, both as to size and number, and in the solution of the quartz grains.

The principal purpose of the microscopic examination of the thin sections was to compare the development of mullite and the solution of quartz in the different specimens both within the body and at the contact of body and glaze. The results of these examinations are given in the following pages.

TABLE I

Sample[1] designation	Rating of mullite development within body	Maximum length of mullite needles at body-glaze contact (mm)	Average absorption of glost ware (per cent)
1a	3	0.010	No data
1b	3	.010	8.67
1c	4	.010	5.81
2a	5	.015	7.74
2b	6	.018	5.14
2c	6	.018	4.08
2d	7	.020	1.11
3a	4–4½	.015	10.42
3b	3?	.010	9.17
3c	4?	.010	7.69
3d	4?	.012	1.86
4a	2	< .010	8.41
4b	5	0.012–0.015	5.56
4c	5	0.012–0.015	4.28
4d	8[2]	.020	0.69
5c	4?	.010	6.06
6a	1[3]	.005?	12.01
6c	4	—[4]	4.15
6d	4?	.008?	3.51

[1] Samples designated by the same number have the same body composition and the same glaze composition. The heat treatments of the unglazed bodies indicated by the small letters are as follows:

a—fired in glost kiln at the plant from which the body was obtained.
b—"cone 6" firing, cone 8 half down inside of saggers.
c—"cone 8" firing, cone 9 half down inside of saggers.
d—"cone 10" firing, cone 11 half down to cone 12 down inside of saggers.

[2] Very large mullite needles within body.
[3] Partially melted feldspar grains. No mullite within body.
[4] Body-glaze contact removed in preparation of section.

[1] "Constitution and Microstructure of Porcelain," Bureau of Standards, *Tech. Paper*, No. 80 (1916).

Sample 1a

Body (Fig. 1) Quartz grains show no perceptible solution. Clay grains have been transformed to extremely minute or incipient mullite needles embedded in an isotropic (amorphous or glassy) medium. In Fig. 1 the angular, glassy grains are quartz and the large, rounded grain with a mottled appearance is a clay grain largely transformed to mullite and glass.

Body

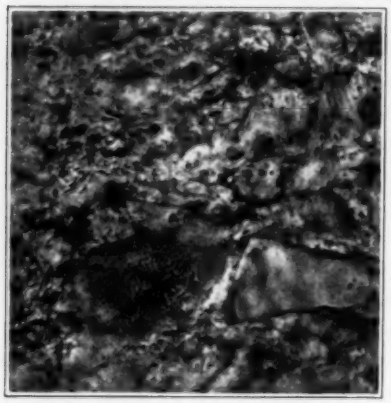

FIG. 1.

Body-glaze contact (Fig. 2) Quartz grains show much solution and rounding of corners. Small mullite needles with a maximum length of 0.010 mm project from the body into the glaze.

Sample 1b

Body Practically the same as 1a.

Body-glaze contact Practically the same as 1a.

Sample 1c

Body The solution of quartz is not perceptible. The mullite needles are slightly larger than in Sample 1a.

Body-glaze contact Much solution of quartz. Mullite needles projecting from the body into the glaze have about the same maximum length as in Sample 1a.

Sample 2a

Body (Fig. 3) Quartz grains show traces of very slight solution. The mullite needles in the transformed clay grains are slightly longer than in Sample 1c. Figure 3 shows a large clay grain in which small mullite needles have been formed.

Body Glaze

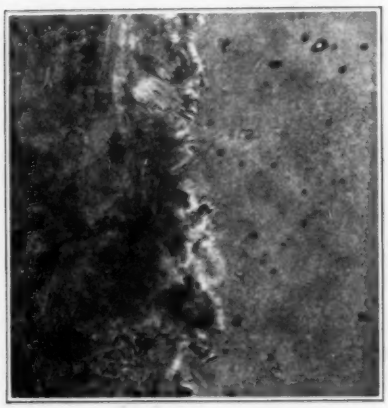

FIG. 2.

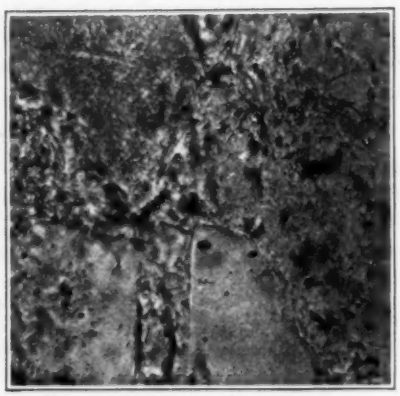

FIG. 3.

Body-glaze contact (Fig. 4) Much quartz solution. Many fairly long mullite needles (maximum length, 0.015 mm) project from the body into the glaze. Mullite needles are apparently more abundant than in Sample 1c.

Sample 2b

Body Quartz grains show very little solution. Mullite needles are slightly longer than in Sample 2a.

Body-glaze contact Much quartz solution. Mullite needles have a maximum length of 0.018 mm.

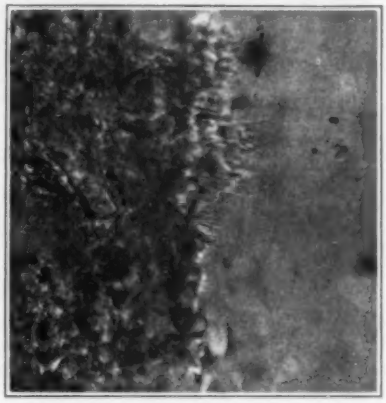

FIG. 4.

Sample 2c

Body.—Practically the same as 2b.

Body-glaze contact.—Practically the same as 2b.

Sample 2d

Body (Fig. 5) Quartz grains seem to have very narrow solution rims. Mullite development is slightly greater than in Sample 2b.

Body-glaze contact (Fig. 6) There has been much quartz solution and relatively few quartz grains are present at the contact. Mullite needles are well developed, the maximum length being 0.020 mm.

Sample 3a

Body Quartz grains show little or no solution. Mullite development is about the same or slightly less than in Sample 2a.

Body-glaze contact Much quartz solution. The maximum length of mullite needles is about 0.015 mm.

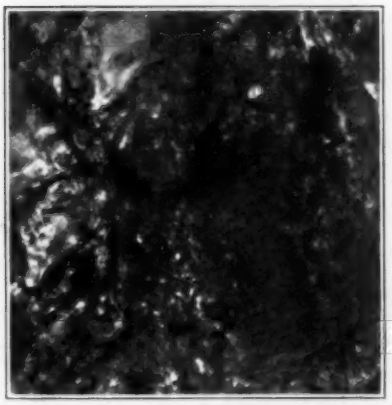

FIG. 5.

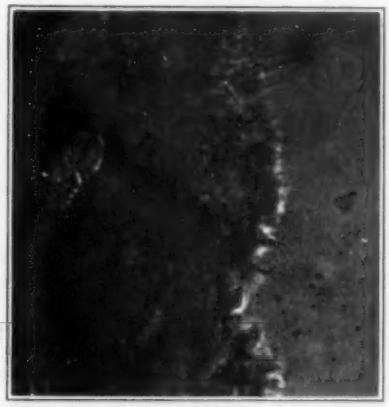

FIG. 6.

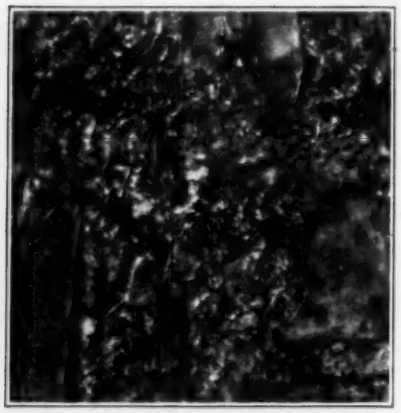

FIG. 7.

Sample 3b

Body (Fig. 7) Very similar in structure to Sample 1a. Mullite needles are incipient or very small. Networks of minute needles are often found within the transformed clay grains. Figure 7 shows an oblong grain containing very small mullite needles.

Body-glaze contact (Fig. 8) The contact is lined with quartz grains showing marked solution and mullite needles (less in quantity than the quartz) with a maximum length of 0.010 mm.

Sample 3c

Body Quartz grains show no perceptible solution. Mullite is somewhat better developed than in Sample 3b.

Body-glaze contact About the same as in Sample 3b.

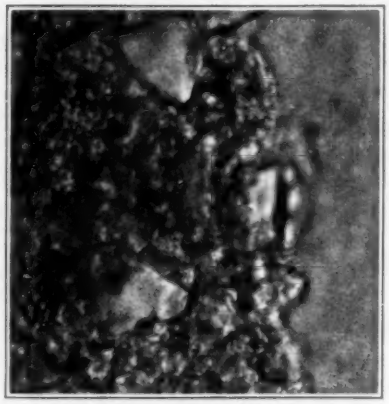

FIG. 8.

Sample 3d

Body (Fig. 9) Quartz grains show very narrow solution rims. Mullite development is rather patchy, some clay grains containing rather long needles, others containing needles so small that they are scarcely distinguishable. Near the lower edge of the photomicrograph (Fig. 9) a clay grain containing fairly long mullite needles can be seen.

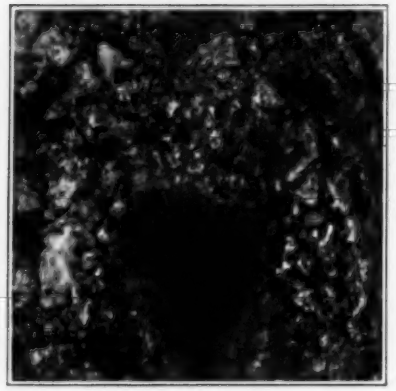

FIG. 9.

Body-glaze contact (Fig. 10) Quartz grains show much solution. Mullite needles attain a maximum length of 0.012 mm.

Sample 4a

Body No perceptible solution of quartz. Mullite needles are very poorly developed. (Often, as in this case, the only indication of mullite formation is the mottled appearance of the clay grains).

Body-glaze contact Much quartz solution. The maximum length of mullite needles is less than 0.010 mm.

Sample 4b

Body (Fig. 11) Clay grains contain networks of fairly well-developed mullite needles. Quartz grains show extremely narrow solution rims.

Body-glaze contact (Fig. 12) Much quartz solution. Mullite needles attain a maximum length of 0.012–0.015 mm.

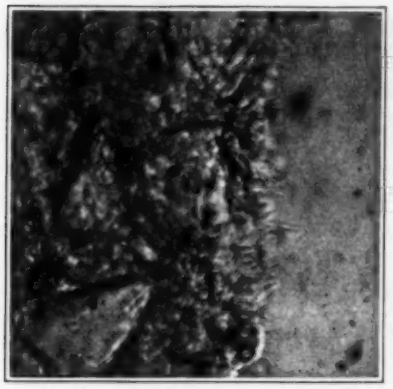

FIG. 10.

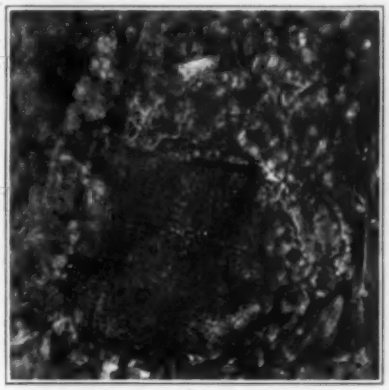

FIG. 11.

Sample 4c

Body Quartz grains are surrounded by very narrow solution rims. The development of mullite is patchy. Some clay grains containing networks of well-developed mullite needles while in some of the grains the needles are small and poorly developed.

Body-glaze contact Much quartz solution. The maximum length of the mullite needles is 0.012–0.015 mm.

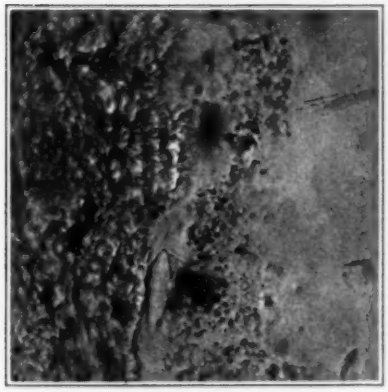

FIG. 12.

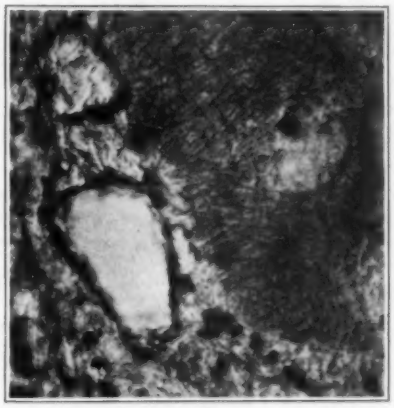

FIG. 13.

Sample 4d

Body (Fig. 13) Quartz grains show rounded edges and narrow solution rims. Clay grains are transformed to masses of well-developed mullite needles.

This body shows the best development of mullite of any body in the series. Note the large clay grain full of long mullite needles in one corner of Fig. 13.

Body-glaze contact (Fig. 14) Quartz grains show marked solution. Mullite needles projecting from the body into the glaze are long, the maximum length being about 0.020 mm.

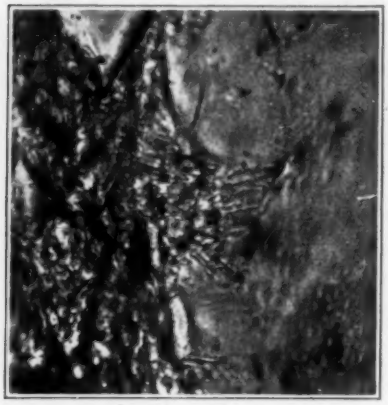

FIG. 14.

Sample 5c

Body No noticeable quartz solution. Clay grains contain minute, often incipient mullite needles. A few grains show masses of well-developed mullite needles.

Body-glaze contact Much quartz solution. The mullite needles are smaller than usual, the maximum length being less than 0.010 mm.

Sample 6a

Body (Fig. 15) The body is composed of quartz showing no evidence of solution, amorphous material and many partially melted grains. The partially melted grains are composed of glass in which crystalline particles are embedded. The grains as a whole retain their original shape and the crystalline portions of each grain extinguish simultaneously between crossed nicols. Since no material for examination as a powder was available, most of the optical properties of the glass and the crystals could not be determined, but the type of twinning found in some of the crystalline particles indicates that the original grains were potash feldspar. The large grain in Fig. 15 is partially melted feldspar, the outer rim of which is fused material. Mullite needles were not observed and clay grains appear as amorphous masses.

Body-glaze contact (Fig. 16) Quartz grains are somewhat dissolved. No distinct mullite needles could be observed although there are some extremely minute (0.005 mm long) needle-like objects which may be mullite.

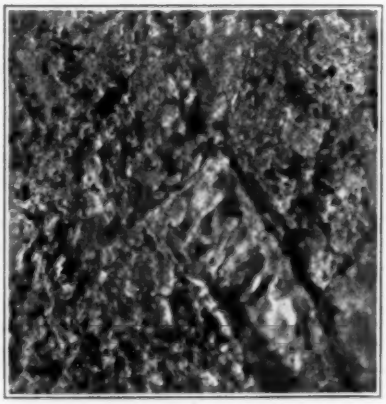

FIG. 15.

Sample 6c

Body Little or no solution of quartz. Mullite development is patchy, some clay grains containing masses of fairly well developed mullite needles, others containing only minute or incipient needles.

Body-glaze contact (Absent, probably having been removed in grinding the section).

Sample 6d

Body Determinations are difficult on account of thickness of the section, but the development of mullite is apparently patchy as in Sample 6c.

Body-glaze contact Quartz grains show much solution but mullite needles are extremely small, the maximum length being about 0.008 mm.

The preceding detailed examinations give results in terms of comparative size of mullite needles. No good method for determining the size quantitatively could be devised and it was, therefore, necessary to rely upon the judgment of the observer. Within the body, mullite had formed in grains of what had originally been clay. This development was patchy in many of the specimens; that is, some of the clay grains contained much larger mullite needles than did others. In estimating the mullite development for the whole body it was necessary, therefore, to examine a large number of clay grains and to average the results.

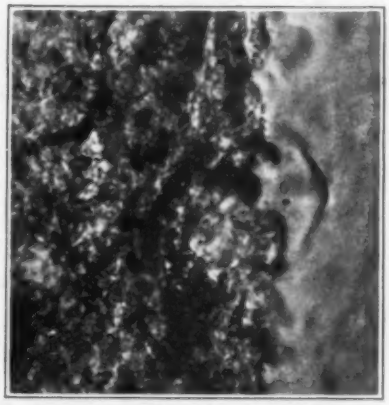

FIG. 16.

Ratings in a scale of 8 have been assigned to each of the samples according to the relative growth of mullite in the bodies. The sample having a value of 1 in the scale is the sample containing no observable mullite needles, while the sample with a value of 8 has the largest mullite needles. The scale value of each sample is given in the second column of Table I. In the third column of Table I is given the maximum length of needles at the contact of body and glaze.[1]

An inspection of Table I shows certain relations between mullite development and heat treatments. In most bodies of the same composition the mullite development within the body and at the body-glaze contact is greater the greater the heat treatment in the bisque firing. In a few instances there is no perceptible difference in the mullite development of a body which has been given a certain heat treatment and of the same body which has been given the next greater heat treatment. This is seen in a comparison of Samples 1a and 1b, 2b and 2c, 3c and 3d, and 4b and 4c. Body 3 apparently shows smaller mullite needles after the refiring at cone 6 than in the first firing in the glost kiln but it must be remembered that only a single thin section was available from each firing and that the thin section may not be representative of the body as a whole.

Although the length of mullite needles at the body-glaze contact is always greater than that of mullite needles within the body, Table I

[1] The miscroscopic examinations, including the determination of the maximum length of mullite needles at the contact of body and glaze, were made before the writer obtained the data on the firing temperature and absorptions of the bodies so that there was no opportunity for his judgment to be influenced by these data.

shows a marked relation between the body and the maximum length of needles at the body-glaze contact; that is, a sample which shows a higher rating than another sample for mullite development within the body also shows a greater maximum length of mullite needles at the body-glaze contact. This is a rather unexpected relation since mullite development within the body is usually considered to be caused primarily by the bisque firing (except where the glost firing is as high as or higher than the bisque firing) while the length of the mullite needles at the contact is certainly due in large part to the action of the molten glaze. Figure 17, a photomicrograph of the body-glaze contact at a magnification of 600 diameters, was taken to show the effect of the glaze upon mullite development. The oblong clay grain near the center of the photograph is, in part, at the contact of body and glaze. In the portion of the grain within the body the mullite needles are small and are unorientated. At the contact, however, the needles are long and are orientated approximately normal to the contact.

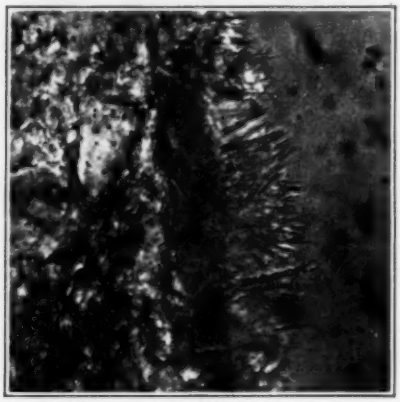

FIG. 17.

It is evident, therefore, that while the growth of mullite needles at the contact is profoundly influenced by the glaze, there is a marked relation of the mullite development at the contact to the mullite development within the body and a somewhat less distinct relation of mullite development, both within the body and at the contact, to the heat treatments in the bisque firing.

DISCUSSION ON "THE EFFECT OF CALCINED CYANITE IN PORCELAIN BODIES"[1]

ABSTRACT

Dr. Navias questions the possibility of mullite development in a feldspar glass and presents observations in his work which seem to support the objection raised. Mr. McDowell views the matter from a thermochemical standpoint and, using a diagram based on the existing data, shows the seeming possibility of mullite developing from feldspar. The entire question is more or less a matter of opinion due to the lack of comprehensive data thereon.

Mullite Development in Feldspar Melts

LOUIS NAVIAS: Correspondence with the authors has elicited the information that the calculations for determining the theoretical percentages of mullite present in the batches represented in Figs. 1 and 2[1] were based upon the chemical analyses of the complete batches. Thus it was assumed that mullite was obtained not only by crystallization in the clay and by recrystallization in the cyanite but also by crystallization of the feldspar. It is the last source of mullite which the writer wishes to question: namely, the possibility of mullite development in a feldspar glass.

In the writer's paper[2] referred to in this article the mullite standard series was made by firing together mullite and feldspar in different proportions. The mullite is found in grains imbedded in a glass. If there is any tendency for the feldspar glass to crystallize, it will do so in the presence of crystals. The mullite crystals added may be considered as "seeds" or "nuclei." Reëxamination of these mixtures under high power shows no evidence of small mullite crystals at the mullite-feldspar glass boundary or in the feldspar glass itself. The mullite fragments are extremely angular in appearance and some of them show slight reaction rims around their periphery indicating solution by the glass. While this is not absolute proof that mullite cannot be crystallized from molten feldspar, it indicates that if it occurs at all, the extent of crystallization must be very small, too small to justify the inclusion in Fig. 2[1] of the quantities of mullite attributed to feldspar disintegration.

A consideration of the melting of potash feldspar is of interest here. Morey and Bowen[3] have determined the solidus-liquidus equilibrium diagram involving orthoclase, and they show that orthoclase melts incongruently. At 1170°C it is converted into leucite crystals and a

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[1] S. J. McDowell and E. J. Vachuska, *Jour. Amer. Ceram. Soc.*, **10** [1], 64–72 (1927).

[2] L. Navias "Quantitative Determination of the Development of Mullite in Fired Clays by an X-ray Method," *Jour. Amer. Ceram. Soc.*, **8** [5], 296 (1925).

[3] "The Melting of Potash Feldspar," *Amer. Jour. Sci.*, **4**, 1–21 (1922).

liquid. The glass formed is highly siliceous. At about 1510° the entire mass is liquid. In terms of the other constituents the breaking up of orthoclase may be written

$$\underset{\text{Orthoclase}}{K_2O \cdot Al_2O_3 \cdot 6SiO_2} = \underset{\text{Leucite}}{K_2O \cdot Al_2O_3 \cdot 4SiO_2} + \text{glass}$$

There is no indication of mullite formation in this system under equilibrium conditions.

Mellor[1] refers to the sluggish melting of orthoclase in the following manner:

> Orthoclase has no sharp melting point. It melts slowly on a rising temperature; while its rate of fusion is small its rate of crystallization must be extremely slow.

The crystallization here referred to is that of orthoclase, but the quotation is included to substantiate the statement concerning the high viscosity of the glass.

Discounting the possibility of obtaining mullite from the feldspar, Fig. 2[2] would then have the following percentages of mullite developed, (it being further assumed that in each case the cyanite is completely dissociated into mullite and glass at the temperatures of firing).

Batches	Per cent mullite development
1, 3, 6, 10, 15, 21	26
2, 5, 9, 14, 20	34
4, 8, 13, 19	43
7, 12, 18	51
11, 17	59
16	68

REPLY BY SAMUEL J. MCDOWELL: The point which Dr. Navias has brought out is one which the writers recognized before publication as being open to discussion. The fact that Dr. Navias found no additional mullite formation from heating mullite feldspar mixtures[2] does not prove that some of the alumina from the feldspar might not go to the formation of mullite under certain conditions. Potash feldspar or orthoclase forms a notably viscous glass and melts of this type are sluggish in regard to crystallization, particularly at low temperatures, and the temperatures used in his work were lower than those used in some of our work.

Viewing the problem from a thermochemical standpoint it seems probable that a portion of the alumina from feldspar does go toward the formation of mullite. Figure 1 shows some of the thermochemical relations of the R_2O–Al_2O_3–SiO_2 system drawn from the data now available which is of course quite incomplete. Orthoclase is found in nature

[1] J. W. Mellor, A Comprehensive Treatise on Inorganic and Theoretical Chemistry, Vol. VI, p. 675 (1925).

[2] L. Navias, *loc. cit.*

associated with silica, leucite, and corundum. It must therefore be in equilibrium with them and is also undoubtedly in equilibrium with mullite although this mineral is very rare in nature. The field of orthoclase therefore must border on the above-mentioned fields. Several other points in the system have been more or less definitely fixed. Morey and Bowen[1] have shown that orthoclase is not stable at its melting point but breaks down into leucite and a melt richer in silica. The composition of this material therefore lies without its stable field. The eutectic between alumina and silica is definitely placed as is the field of mullite in mixtures of these two components.[2] Vogt[3] has stated that the eutectic between orthoclase and silica lies in the region 75% orthoclase, 25% silica. With these points located the fields were sketched as shown.

All bodies in our investigation and practically all normal porcelain bodies fall within the composition triangle SiO_2–O–M as shown in Fig. 1. The composition of body No. 11 is designated as being typical. As bodies in this field are heated the first liquid to form is shown by point *A* and the heating is usually continued until all the feldspar is in solution. If the composition of this eutectic *A* is lower in alumina than orthoclase as seems likely, this excess should, on cooling, combine with silica and form mullite.

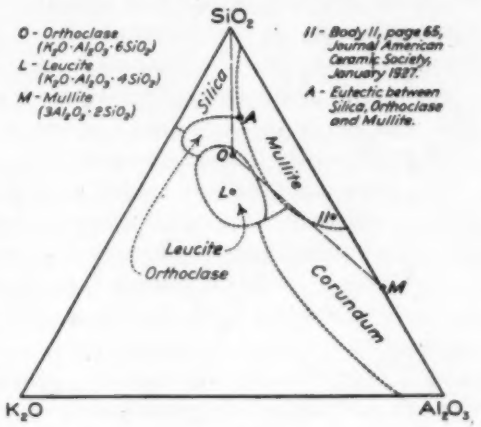

FIG. 1.

It was this belief which caused the writers to add alumina in the feldspar in predicting the probable amount of mullite formed in the bodies. There was never any thought that all the alumina from this source was thus used but it seemed probable that a portion was so used and not knowing what that portion might be the total amount was figured.

It is hoped that the relations of this very interesting field may soon be established by a research such as that of the Geophysical Laboratory but until this is done such questions as this must remain matters of opinion.

[1] Morey and Bowen, *loc. cit.*

[2] N. L. Bowen and J. W. Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.* 7 [4], 238–54 (1924).

[3] J. H. L. Vogt, Die Silikatschmelzlosungen, Part II, p. 124.

AN INTERESTING COLOR PROBLEM[1]

By H. Spurrier

ABSTRACT

A terra cotta glaze that had not previously shown any color suddenly burned to a pink. The cause of the color was found to be chromium communicated by the kiln atmosphere. An exceedingly delicate test for chromium and an interesting use of complementary color effects were developed.

It is not an uncommon experience in firing white enameled terra cotta to find that it picks up chromium in the kiln, and the result is that, instead of a clear white, a distinctly pink-hued enamel results, the color intensity being great enough to cause rejection. A pink color may also arise in the presence of tin, from high lime and low zinc content, but it was not the case in this instance.

A certain white enamel which had never before picked up color, and was per force considered immune, suddenly developed a pink shade sufficiently deep to cause rejection.

The previous excellent record of this glaze seemed to preclude the obvious inference of "stealing," and consequently the occurrence was considered worthy of an effort to determine its cause.

Accordingly a liberal sample was placed in the writer's hands with the request to find both the cause and origin of the color. A strong personal conviction was entertained that, notwithstanding the perfect record, this was another case of "stealing"; but since personal convictions are neither evidence nor proof, it became necessary, if possible, to correct or corroborate this conviction.

A careful microscopic examination of pieces of the enamel, flaked off from the body with a fine chisel, was made upon sections parallel and normal to the surface of the original enamel. This showed that the color was entirely superficial and did not penetrate the enamel appreciably.

The color was located in small spots of rather greater opacity than the contiguous areas, although, to the unaided eye, the color appeared uniform. These spots proved to be rich in tin oxide.

If the upper surface was ever so slightly ground away and the specimen polished, no pink color whatever could be detected.

The next step was to make a very thorough examination of the enamel constituents for chromium, in which minute traces of that metal if present, could be unerringly detected.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Terra Cotta Division.)

It now became necessary to secure a test for chromium of great delicacy, and this was achieved by the use of diphenyl carbazide $CO(NH.NH.C_6H_5)_2$. Two decigrams of diphenyl carbazide was dissolved in 5 cc glacial acetic acid, and the solution made up to 25 cc with pure methyl alcohol.

In order to test the delicacy of the reaction, a solution containing two parts of chromium per million of solution, was made up, using chromate of potassium as a source for the metal. Two tubes about one inch inside diameter, and eight inches long, were used for the test and the blank. On addition of the reagent to the chromate solution, a deep violet pink color developed almost instantly, being characteristic of the presence of chromium. The solution was diluted to one part in ten million, and even at this dilution, the test was very positive. Finally, the diluency was increased to one part in twenty million, and even at this strength, a very definite and positive color test was secured.

With all tests, blanks were run, and it was found essential to wash with hot hydrochloric acid and water several times to free the tubes from the chromium of previous tests. Having secured a sufficiently delicate test for the suspected metal, it was applied to the raw materials, with the result that the lead oxide gave a slight, but distinct, reaction. It was considered that the amount of chromium found in the lead oxide was entirely inadequate to produce the color in the enamel on account of the small amount of chromium that would be introduced in this manner. No ingredient in the enamel showed chromium other than the lead oxide.

A considerable sample (about 3 grams) of the enamel was chipped from the terra cotta and cleaned from adherent body, then finely ground in a specially cleaned agate mortar. The powdered material was then fused in C.P. sodium carbonate, digested in water, acidified, and evaporated to dryness. It was then taken up in water, and filtered, rendered faintly acid with acetic acid, and the test applied, resulting in a definite and positive reaction. A companion blank was run in parallel, which gave a negative result.

As it is rare that the kilns are fired without containing chrome in some form or other, it was decided to make a test on the kiln atmosphere for chromium. Accordingly, a sample amounting to 48 liters of kiln gases was aspirated through very dilute sulphuric acid, contained in a 10-bulb Meyer tube. The taking of this sample occupied 24 hours. The contents of the Meyer tube were neutralized with sodium carbonate slightly acidified with acetic acid, and the test applied, giving a positive result. A blank run on washed and filtered air gave a negative result. The following points had now been definitely established:

1. The color on the enamel was on, and not in, the enamel, in the sense of distribution.
2. The color was mottled, such mottling having high tin areas as neuclei.
3. The colored enamel contained chromium in amount greater than its original constituent ingredients. (The reaction for chromium on the enamel was considerably stronger than the same reaction obtained with the lead oxide.)
4. The kiln atmosphere carries chromium.

While the above findings do not constitute absolute proof of the source of the chromium that gave the color, the circumstances are such as to render the assumption of "stealing" inescapable.

It now became very desirable, if possible, to elaborate some method of discharging the pink tint on the undesirably colored terra cotta. A few experiments were made, none of which were entirely successful, but the summing up of these experiments pointed the way to the method that finally succeeded. The experiment was conducted as follows:

A Hoskins' tube furnace was equipped with a quartz tube, which carried at its center a loose plug of asbestos which was followed by a few inches of coarsely granular charcoal, then another plug of asbestos followed by a one-hole rubber stopper, to which was fitted a glass tube which was to deliver dry carbon dioxide. The furnace was heated to a red heat, and a piece of the pink tinted terra cotta was introduced at the end opposite from the CO_2 delivery tube. This piece of terra cotta had been previously so shaped that the maximum surface of the enamel was secured. The quartz tube was now closed with another rubber stopper carrying a glass tube bent at a right angle, and pointing horizontally with its tip in juxtaposition with a small burner, intended to burn the issuing carbon monoxide. The furnace was heated up, and the CO_2 gas was now passed slowly into the tube. As it passed the red hot charcoal, the following reaction took place: $CO_2+C=2CO$. After about fifteen minutes the piece of terra cotta was removed and on cooling was found to have been freed entirely from the objectionable pink shade. This experiment was repeated at different temperatures, involving different time factors, even as short a period as three minutes, which was found to be sufficient to remove the pink color. It will be noted that the atmosphere was highly reducing.

It is commonly considered that when a kiln gas shows no free oxygen, the atmosphere is necessarily reducing, but this is not true, as is shown by the above reaction. Since carbon dioxide may be reduced to carbon monoxide, it is obvious that, under some circumstances, carbon dioxide may act as an oxidizing agent, as it did on the heated charcoal. This is, of course, very evident, but it sometimes escapes attention.

During the progress of the above work an interesting side light was cast upon the question of apparent color and the color perceptiveness of different eyes. The writer is not color blind, but has not a very keen color perception, and he found that trained eyes could perceive pink tints which were not visible to himself. It was conjectured that if a cell could be devised, the color of which should be complementary to pink, then by observing delicate pink shades through such a cell, the shade viewed through the cell would appear nearly white, and present a visible contrast with the same shade viewed beside, but not through, the cell. Accordingly, a weak solution of chromate of potash was made up, and to this was added a dilute solution of sulphate of copper rendered slightly ammoniacal under the belief that possessing most of the colors beyond the pink, and toward the violet end of the spectrum, such a mixture would be complementary to the pink and have the desired effect. A small cell 3 mm thick made of two microscope slides, separated by a piece of glass rod, 3 mm diameter, bent twice at right angles, forming a rude U with a distance somewhat less than one inch between the longer members of the U. The glass slides were then cemented on to either side of the U with Bakelite cement. On filling the cell with the above described solution, and viewing the slightly colored terra cotta through it, the contrast was almost startling. If a slightly pink specimen of terra cotta is viewed intently for about thirty seconds through the cell, and the cell suddenly removed, the area viewed appears of a much intensified color, such intensity persisting for an appreciable time. It does not require much imagination to see that other applications of this device might be made with very useful effect, and for that reason it is here described.

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SOME OBSERVATIONS ON THE AGING OF ENAMELS[1]

By H. G. Wolfram and R. H. Turk

ABSTRACT

The tendency toward more rapid production of enameled ware has reduced to a minimum the time allowed in most plants for aging of enamels. Aging of the enamel slip allows the clay to become thoroughly slaked, adsorb the larger enamel particles, and thus prepare it for its cohesion to the metal base. Aging or soaking of the clay before use is an excellent substitute for part of the time consumed in aging the enamel slip. Observations of results obtained in commercial application of enamels has lead to the following conclusions: (1) Enamels should be aged before use in order to gain the full benefit of the adsorption properties of the clay and enamel colloids. (2) If the proper time of aging of enamels cannot be allowed, at least the clay should be brought to a fine state of subdivision by aging or soaking in water. (3) If aging is not allowed in some form, the enamel usually is not as easily applied with the ordinary handling encountered in average production. (4) If aging of the clay is allowed there is a quicker turn over of the stock enamel in the mill room.

I. Introduction

Manufacturers have realized for many years the importance of aging of enamel slip. This practice of aging, no doubt, was introduced with the adoption of wet process enamels for sheet steel and was suggested by the methods of the potter who for centuries has aged his clays. With the present day tendency toward rapid production and speed of manufacture, many enameling plants have outgrown their mill room capacity to the point where less and less time is allowed to lapse between the milling of enamels and the application to the ware.

About a year ago a manufacturer stated that he was using his enamels so fast that it was necessary for him to apply it almost immediately after drawing it from the mill. It was necessary for him to exercise considerably more care in the shop. Observations of this character, experiences with unaged enamels, and literature reviewed during the past year have led to the belief that aging is essential to the successful application of enamels with the present day average supervision, especially where clay is used in the suspension. It is not meant by this that unaged enamels cannot be applied, but rather that they are less fool-proof and should be considered so. It is believed that the importance of aging cannot be too strongly stressed.

II. Mobility and Yield Value

Relation to Aging

A complete and thorough investigation of this subject would involve considerable time and energy, since the theory of colloids and colloidal chemistry is involved.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Enamel Division.)

W. N. Harrison,[1] of the Bureau of Standards, has touched upon the subject in his investigation of the physical and chemical properties of enamel suspensions. He states that in obtaining slips of the desired consistency, mobility is controlled by water content while yield value is controlled by varying the colloidal content and the state of its flocculation. In his experiments he found that aging lowered the yield value. Cooke[2] says that the desirable condition of an enamel is a yield value commensurate with the thickness of coating desired, and a high mobility. Both Harrison and Cooke found that increasing the water content increased the mobility and reduced the yield value somewhat. Also that borax and magnesium sulphate increased the yield value considerably without changing the mobility.

By a manipulation of these various factors, it would be possible to obtain an enamel slip of the proper consistency for application. However, it is necessary to have a slip to start with, which can be manipulated. Hence, if an enamel has a low yield value, this property can be increased to the proper point by the addition of borax or magnesium sulphate without changing the mobility. This happens when an enamel is "set up" before use.

Aging then reduces the yield value to a point where it can be brought back to the proper consistency by quick artificial means. This reducing of the yield value is desirable where it can be brought about without materially changing other properties of the slip such as, for instance, the specific gravity. The addition of water as has been stated before, will reduce the yield value somewhat, but it also reduces the specific gravity and therefore should be used to reduce the yield value only in the finer adjustments of this property. Aging then is the proper method of reducing the yield value since this is accomplished without materially disturbing the other properties of the slip.

III. Aging of Clay

Adsorption Harrison[1] found that enamel frit ground in water contained considerable particles of colloidal size. Searle[4] says that souring or aging is a disintegrating change which takes place in a clay paste and is dependent to some extent on the size of the clay particles. Some consider aging due to a colloidal phenomenon or the slaking of the clay to particles of colloidal size. These colloids are characteristic in that they retain their plasticity when mixed with non-

[1] W. N. Harrison, "Controlling the Consistency of Enamel Slips." (Not published).

[2] R. D. Cooke, "The Plastic Properties of Enamel Slips," *Jour. Amer. Ceram. Soc.*, 7, [9] 652 (1925).

[3] Searle, The Chemistry and Physics of Clays and Other Ceramic Materials, Benn Brothers.

plastic material which is a special case of adsorption of one solid by another.

This adsorption, no doubt, is taking place in an enamel slip and therefore explains to some extent at least the suspending property of the clay content. The enamel ground to particles of colloidal size also aids in this suspension and perhaps is the reason why certain enamels require no clay to keep them from settling.

Slaking of clay occurs when water is added to it, thus reducing the size of the particles of clay to a point where the separate and individual colloidal particles can move freely in the mass and adsorb other particles. Time is required for this to take place and when the clay is in an enamel slip it must be allowed to be thoroughly distributed through the slip in order that the full benefit of its suspending properties can be realized.

Also, according to Searle,[1] coarser particles have much smaller surfaces and consequently have far less power of adsorption. The cohesion of plastic clay to iron is an example of adsorption. If the clay or enamel is not plastic, or in other words, has not a sufficient proportion of particles of colloidal size it will not adhere to the iron. This may explain why new enamel from the mill unaged has a tendency to crawl or curl.

One investigator[2] in Germany found that kaolin would adsorb from 0.4 to 1.7% of its own weight of copper oxides from a solution containing copper sulphate. Clays then will adsorb soluble salts from their solutions and seem to have the ability to select either the base or acid ion. This adsorption is not brought about in an hour or a day, since as was pointed out before, some time is required to slake the clay or bring it to the proper fineness so that these various phases of adsorption can take place.

The adsorption of water by clay, as Searle[1] states, is a very complex phenomenon and has never been properly explained. It has the ability if dry and brought in contact with water, of absorbing a large quantity of water without losing its solid character. However, as soon as this water is absorbed slaking of the small particles takes place and aging starts.

IV. Results Obtained with Aged Clay

During the war, enamelers had some difficulty in obtaining clay sufficiently free from dirt to use in white enamels. Various methods were used to remove the dirt. Our company put the clay in a barrel and wet it down with the hope that some of this dirt would settle to

[1] *Loc. cit.*

[2] A. Bencke, *Sprechsaal*, 53, 490–91 (1920).

the bottom if allowed to remain there a sufficient length of time. This did not occur, however, so that it was noticeable, but since the clay absorbed the water and retained its solid character, other and perhaps more beneficial results did show themselves.

In weighing this wet plastic clay for a mill charge, account was taken, of course, of the water in the clay and when figured at about 20%, more wet clay was added than would have been added if dry. It was soon found, however, that the amount of water per mill charge had to be cut down considerably. The mill charge with dry clay consisted of 6% clay, 7% opacifier, and 50 to 55% of water. The opacifier certainly takes up a certain amount of water. Since that time the opacifier added at the mill has been reduced considerably, but this fact would not account for the necessary reduction of water. At present 7% of the wet clay is added and only 36% of water. Figuring this on a basis of 100 pounds of frit, 7 pounds of wet clay are now added in place of 6 pounds of dry clay originally. If 20% of the wet clay is water, then instead of the clay content being the same as before it actually is less. The water added with the wet clay is only 1.4 pounds, which certainly does not account for a reduction of water in the batch from 55 pounds to 36 pounds. The large excess of water added to the mill was used to reduce the yield value to a point where it could be drawn off readily. The enamel after standing or aging had an excess of water on the surface which was skimmed off and thrown away before the enamel was used. The aging of the clay has reduced the yield value of the enamel in the mill so that it does not require the extra water to make it flow readily.

When the dry clay was used it was found that during the grinding, it was not thoroughly mixed with the enamel. Small and even large lumps were sometimes noticeable in the enamel slip. In other words, the clay was not slaked properly. This condition is never encountered with the wet or aged clay (10 days to three weeks aging.)

It was found also that the enamels did not have to be aged very long before they could be regulated to the proper consistency for use. The time of aging was cut down considerably because the clay was already aged. It was in that fine state of subdivision necessary for it to adsorb the larger particles of frit. The time of aging then was only the time required for this adsorption to take place (about 2 days). Then the turnover in the mill room was quicker and there was less investment in stock enamel in the process of aging.

V. Conclusion

It is believed, therefore:

1. That enamels should be aged before use in order to gain the full benefit of the adsorption properties of the clay and enamel colloids.

2. That, if the proper time of aging of enamels cannot be allowed, at least the clay should be brought to a fine state of subdivision by aging or soaking in water.

3. That, if aging is not allowed in some form, the enamel is not as easily applied with the ordinary handling encountered in average production.

4. That if aging of the clay is allowed there is a quicker turnover of the stock enamel in the mill room.

VI. Summary

The writers have tried to show some of the beneficial effects resulting from the aging of enamel slip or the clay used in the suspension and through various references, to explain at least partially the reasons why aging should be allowed to take place. There are special cases when aging is not beneficial but these are rare and seldom encountered except in certain lines of the industry. There are also a few cases where the enamels are aged for months before use, but the general practice seems to be from two days to two weeks.

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NOTE ON THE SOLUBILITY OF ENAMEL FRIT IN MILL WATER[1]

By H. L. Cook

ABSTRACT

Methods of determining the solubility of enamel frit in mill water are outlined. Various tests tried show that (1) solution increases as fineness increases, (2) mixing has little or no effect upon solubility, (3) variation of smelter treatment has little or no effect upon solubility, and (4) Na_2O and B_2O_3 will dissolve from a dry ground frit proportionately to the fineness thereof.

Introduction

Periodically the white enamels in use in our plant would not fire to their usual smooth finish, but would pinhole. After much investigation, this phenomena was found to be caused by the burning out of crystals of borax which had formed as the sprayed enamel was drying. These crystals formed usually when the enamel dried very slowly. Such crystals could readily be detected, and appeared to be borax. A microscopic examination of the unfired enamel surface, and a chemical analysis of the mill liquor was made by a firm of competent analytical chemists. Their report was that such crystals were of borax.

Literature

A review of the available literature failed to disclose any information upon the solution of enamel frit in mill water that had any bearing on this problem.

Purpose of Investigation

This investigation was carried out to determine, if possible, the causes of solution of enamel glasses when ground with water. It was felt that such an investigation should study the mixing of the raw materials, the smelting, and the grinding.

Physical and Chemical Analyses

A microscopic examination was made of the enamel powder which had been scraped from ware which had dried very slowly, and in which crystals were present. The crystals found were those of borax.

Chemical analysis of the mill liquor from this enamel slip and in the water before milling is given in Table I (figures in grains per U. S. gallon).

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Enamel Division.)

TABLE I
MILL LIQUOR

Total Minerals	Mill liquor	Water
solids in solution	1224.31	41.65
Composed of:		
Siliceous matter	4.90	1.65
Alumina	0.48	0.19
Oxide of iron	0.00	0.01
Sodium carbonate	95.84	
Sodium sulphate	60.79	6.91
Sodium chloride	32.35	14.41
[1] Sodium borate (Borax)	1029.95	
Calcium carbonate		10.31
Magnesum carbonate		8.17

[1] The percentage of sodium borate was 1.76 of the weight of water analyzed, but was 84% of the total solids.

Composition of Enamel

The enamel studied in this investigation had a melted composition of:

Feldspar	34.78	Sodium silico-fluoride	7.09
Silica	21.26	Cryolite	7.09
Boric oxide	13.78	Fluorspar	4.72
Sodium oxide	8.92	Antimony oxide	2.36

Milling of Enamels

Prior to milling of the enamel glasses, the frits were thoroughly dried. Upon charging the mill, to the weighed amount of frit was added 6% of Vallendar clay, 40% of water, which was weighed, and the usual percentage of opacifiers. These weights were checked very carefully, for to obtain comparable results, no variation could be allowed in water, glass, or any other contents.

Determination of Fineness

To determine the degree of fineness of enamels, 270 cc of the enamel slip was measured out, and this slip washed through a 150-mesh sieve by running water. After drying, the residue was weighed, and the weight so obtained in milligrams was considered the factor of fineness.

Method of Analysis of Mill Liquors

Throughout the investigation, mill liquors were analyzed as a means of learning the solubility of the frit. The enamels were allowed to settle, and 10 cc were taken for analysis. Since the water content was the same in every case, the soluble salts in 10 cc would be a means of comparison. As all other items were negligible, only the Na_2O and B_2O_3 contents of the liquors were determined.

Na_2O was determined by titration with $N/5$ HCl, using methyl orange as an indicator. Multiplying cubic centimeters of acid consumed by .0062 gave the amount of Na_2O present.

B_2O_3 was determined by titration with *N*KOH, using phenolphthalein as an indicator. The solution was first neutralized with HCl, boiled to expel CO_2, cooled, and an equal volume of neutral glycerol added to bring about a more stable compound containing B_2O_3. Boric oxide was then determined by multiplying the number of cubic centimeters of KOH consumed by the factor, .035.

Borax was determined from the B_2O_3 content, multiplying by the factor, 2.7307.

This method of analysis is the one outlined by R. D. Landrum.[1]

The Investigation

Varying the Degree of Fineness

The first work of the investigation was to learn at what stage of the grinding solution of the frit occurred. For this work a 600-pound batch of enamel was milled, and 25-pound samples were drawn at intervals during the grinding. Fineness was determined as previously mentioned. After settling, these liquors were analyzed. Table II gives the results of these tests.

TABLE II

Sample no.	Grinding hours	Grinding revolutions	Fineness test	10 cc liquor contained. grams. Na_2O	B_2O_3	Borax	Excess Na_2O
1	5	8240	No test	.0198	.0245	.0669	.0087
2	7	11812	" "	.0242	.0280	.0765	.0118
3	9	15100	6110	.0291	.0315	.0860	.0152
4	11	18000	1770	.0338	.0385	.1053	.0167
5	13	21680	390	.0397	.0490	.1339	.0180
6	15	25270	180	.0490	.0595	.1625	.0227
7	17	28650	135	.0558	.0700	.1911	.0249
8	19	32630	125	.0713	.0840	.2293	.0341
8	NOTE			.0744	.0910	.2485	.0338

NOTE: Liquor from No. 8 was titrated 13 days after milling. The enamel had been thoroughly stirred every two days. The container had been thoroughly sealed to avoid loss from evaporation.

From the above, it is very evident that solubility of the glass increased with increased fineness. The greater surface area exposed to the water, and increased time in the water increased the degree of solution. Increased solubility also occurred by merely agitating the particles periodically over a considerable period of time. Short milling time on very fine particles greatly increases the solubility in the mill water.

Dry Grinding of Enamel Glass

To determine if the finely divided frit would dissolve in water, the same enamel glass was ground dry. After milling to approximately standard fineness, a sample of the dry powder was mixed with

[1] "Analysis for Enamel and Enamel Raw Materials," *Trans. Amer. Ceram. Soc.*, **12**, 156 (1910).

40% of water by weight. To the balance, the regular mill charge was then added, and milled with this mill charge for five hours. After settling, the liquors were analyzed. Results are given in Table III.

TABLE III

Description	10cc of liquor contained in grams			
	Na_2O	B_2O_3	Borax	Excess Na_2O
Powder mixed with water	.0310	.0385	.1053	.0140
Powder milled with mill charge	.0515	.0630	.1720	.0236
Powder mixed with water, 48 hours after mixing	.0372	.0420	.1145	.0186

It is evident that the enamel frit was in such a state that upon fine grinding, and merely mixing with water, solution occurs. Five hours grinding practically doubled the amount of Na_2O and B_2O_3 in solution.

Mixing of Raw Materials

To note the effect of the mixing of the raw materials, three batches were smelted.

Batch A–I after weighing was piled in a cone, and shoveled over twice. No lumps were broken. The mixing was not very thorough.

Batch A–II was weighed, piled in a cone, shoveled over six times, and all lumps broken up by hand.

Batch A–III was weighed, sieved through a ten-mesh sieve, and mixed in a mechanical mixer.

These batches were smelted in a flat-bottomed smelter under identical conditions, namely, almost constant smelter temperature, and identical smelting time. Each batch was thoroughly puddled two times.

These frits were milled as outlined in the section referring to milling of glasses. The glasses were milled consecutively on the same mill, the same length of time, and approximately the same number of revolutions. The results of this series are listed in Table IV.

TABLE IV

Batch	Fineness test	10cc of mill liquor contained in grams			
		Na_2O	B_2O_3	Borax	Excess Na_2O
A-I	128	.0744	.0770	.2102	.0403
A-II	120	.0713	.0735	.2007	.0388
A-III	130	.0729	.0753	.2056	.0396

The mixing of the raw materials has very little effect upon solubility. Upon grinding to comparable fineness, the amounts of Na_2O and B_2O_3 obtained were practically the same. Although there is a variation in the results obtained, as far as solubilities go, these results are only slight, and would make no great difference on the crystallization of borax upon slow drying of sprayed enamel plates. The effect of mixing was also checked with enamels outside the scope of this paper, and it seems that the mixing has very little effect upon ultimate solubility.

Varied Smelter Treatments

The next step in the investigation was to note the effect of varied smelter treatments. Mixing of the raw materials was identically performed by intimate shoveling.

Batch B–I was one which was given the usual smelter treatment. It was smelted in the factory flat-bottomed smelter, and before drawing was thoroughly puddled twice.

Batch B–II was a batch as above, except that it was not puddled.

Batch B–III was smelted as B–I, except after quenching and drying was returned to the smelter and resmelted. Before drawing, the batch was again puddled twice.

Batch B–IV was a small batch which was smelted in a small rotary smelter. Before mixing, it was sieved through a ten-mesh sieve, then mixed very intimately.

Batches B–I, B–II, and B–III were milled under the usual comparable milling conditions. Batch B–IV was ground in a small mill to the same fineness.

The results of this series are listed in Table V.

TABLE V

Batch	Fineness test	10 cc mill liquor contained in grams			
		Na_2O	B_2O_3	Borax	Excess Na_2O
B–I	122	.0744	.0753	.2055	.0411
B–II	126	.0760	.0770	.2102	.0419
B–III	120	.0793	.0805	.2198	.0437
B–IV	131	.0490	.0525	.1434	.0258

Smelter treatment in a flat-bottomed smelter has little or no effect upon the amount of Na_2O and B_2O_3 which will be dissolved upon grinding. It seems evident that a rotary smelter tends to reduce the solution tendency, but in this case, the enamel obtained upon milling would deposit crystals of borax upon slow drying.

Conclusions

(1) It is evident that solution increases as fineness or surface area increases.

(2) Thorough mixing has little or no effect upon solubility.

(3) Thorough smelting, puddling, or resmelting has little or no effect upon solubility.

(4) Upon dry grinding, the enamel frit is in such a state that Na_2O and B_2O_3 will immediately dissolve from the frit.

Acknowledgment: The writer wishes to express his appreciation of the interest and help of B. T. Sweely.

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OBSERVATIONS UPON THE EFFECT OF VARIOUS ELECTROLYTES WHEN ADDED TO ENAMEL SUSPENSIONS MADE WITH AND WITHOUT CLAY[1]

By H. L. Cook

ABSTRACT

The literature is reviewed. The effects of various electrolytes on a clay slip, an enamel slip, a finely ground clay-sand-water suspension, and a finely ground sand-water suspension were observed. "Setting up" of water suspensions of finely divided insoluble materials seems more dependent on fineness of grinding and degree of solution of the suspended material than upon the presence of clay.

Introduction

In a plant where an enamel frit was milled without clay, it was observed that this enamel suspension would react with magnesium sulphate. It was decided to study this phenomena further for it has been the prevalent assumption that clay must be present in an enamel suspension or the electrolytes would not be effective.

Literature

A review of the available literature disclosed little light upon the subject of setting or stiffening of enamel suspensions. Theories are advanced, and in some cases, widely divergent opinions are expressed.

Grunwald[2] devotes a chapter to "The Stiffening of Enamels." He admits that

> Only modern physical chemistry is in a position to explain certain phenomena connected with the setting of enamels, especially such facts as the capability of an enamel to be set or stiffened by the addition of acids such as HCl, bases like ammonia, caustic soda, or salts such as $MgCl_2$, $MgSO_4$, $Na_2B_4O_7$, etc.

Further on he states,

> The real action during the setting of an enamel is bound up with the presence of clay as a grinding addition. An enamel ground without clay is scarcely capable of being stiffened. The setting of enamels, brought about by the influence of vehicles, must accordingly be traced to an action between clay and electrolyte.

Later in the chapter he again adds,

> The stiffening power of a vehicle is bound up with the presence of clay in a moist ground enamel.

Staley[3] in a section on "Flotation of Enamels" discusses the action of electrolytes. As chemical vehicles he lists, boric acid, vinegar, HCl and H_2SO_4 and also $MgSO_4$, and $MgCl_2$. He then adds,

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit Mich., February, 1927. (Enamel Division.)

[2] "The Technology of Iron Enameling and Tinning."

[3] Bur. of Standards, *Tech. Paper*, No. 142.

It is a noteworthy fact that none of these chemical vehicles has any appreciable effect unless clay is present. It would seem, then, that the effect of these reagents is to coagulate the clay, and thus render it capable of floating the enamel.

Observations

Having noted upon various occasions that $MgSO_4$ will set or stiffen a suspension of enamel frit in water without clay, various experiments were made. The following electrolytes were used: $MgSO_4$, $Mg(OH)_2$, $BaCl_2$, $(NH_4)_2CO_3$, $Ca(OH)_2$, $CaCl_2$, $Na_2B_4O_7$, NaOH, and concentrated H_2SO_4. To get comparative tests equal amounts of these electrolytes were added to standard amounts of suspensions.

It was first thought advisable to note the action of the various electrolytes on a clay slip. For this purpose, a slip of Vallendar clay was made. This slip was of the approximate consistency of enamel slip, and contained 65% water. Water from this slip failed to show either an acid or basic reaction with ordinary indicators.

Adding $MgSO_4$, the slip was stiffened slightly, although the viscosity was never increased to the point that enamel slips can be stiffened. NaOH in concentrated solution had an appreciable setting action. $BaCl_2$ and $CaCl_2$ stiffened slightly, while with $Na_2B_4O_7$ and $(NH_4)_2CO_3$ a setting action could not be observed. Upon raising the water content of this slip, and then adding the electrolytes, a point was soon reached where $MgSO_4$ had no setting action whatsoever and merely diluted the slip. It seems possible that if a slip could be obtained using 40% of water, the amount used in enamel slips, the action of electrolytes would be identical to their action upon enamel slips. The added water seems to retard the setting or stiffening action.

The action of the various electrolytes was next tried on a white enamel slip. This glass was milled with 36% of water, and no clay or other mill additions were added. This enamel was milled until only 150 mg. of glass was retained on a 150-mesh sieve after washing through 270 cc of the slip.

Mill liquor obtained from this enamel was analyzed. Ten cubic centimeters of this liquor contained .1100 gram of borax, and .0312 gram Na_2O above the amount required for the borax.

This enamel was stiffened by the addition of each of the electrolytes studied. $MgSO_4$ had a decided stiffening effect. The viscosity can be so increased that a ball of the suspension will retain its shape. The action of $BaCl_2$, $Mg(OH)_2$, and $CaCl_2$ is even more marked. H_2SO_4 will stiffen the slip until acidity is developed, when all initial viscosity is lost, and the slip will run like water. Borax and $(NH_4)_2CO_3$ have only a slight setting action.

Thinking that the substances dissolved during milling from an enamel glass might accelerate or cause the setting action, a mixture

of silica sand, 5% of Vallendar clay, and 40% of water was milled to the same fineness as the previous enamel slip. In such a suspension, when the various electrolytes were added, an increase in viscosity was noted. In every case, the action was closely identical to the setting noted in clay-water-enamel suspensions, or in enamel-water suspensions.

The mill water from this batch was analyzed, but no acid or basic reaction could be noted.

To see what effect the various electrolytes would have on a substance doubtless very insoluble in water, and to which no colloidal matter was added, silica sand was milled with 36% of water with no clay added. Again this was milled to the fineness of other slips. Here again the various electrolytes increased the viscosity of the slip. With $MgSO_4$, $BaCl_2$, and $Mg(OH)_2$ it was possible to get very stiff suspensions, and to use a plain expression were "stiff as mud." The addition of a slight amount of concentrated H_2SO_4 reduced the viscosity of the original slip until it ran from the fingers like water.

A ground coat enamel was milled with water without clay or other mill additions. Here the enamel was milled only until 250 mg. of the enamel was retained on a 150-mesh sieve after washing through 270 cc of the enamel slip. With this slip, the viscosity increased by adding electrolytes, although not so markedly as in finer ground slips.

Summary

The phenomenon known as "setting up" or the stiffening of water suspensions of finely divided insoluble materials, does not seem to be dependent upon the presence of clay, since, as noted above, suspensions without clay react vigorously, while water suspensions of clay alone do not react to the same extent.

It was not possible to get a setting reaction with any electrolyte in a clay slip that would have the same water content of the clay slip in which enamel particles are suspended in enamels.

It would seem, therefore, that the fineness of grinding, and degree of solution of the suspended material are more important factors in enamel suspensions than the floating properties of the clay used.

It is not the purpose of this paper to offer any explanation of the phenomena observed. It seems possible, however, that electrolytic charging of colloidal particles comes into play.

The writer does not advocate making enamel suspensions without clay, because, for one thing, enamels to which clay has been added are more easily handled after drying on ware than clayless enamels.

Acknowledgment: The writer wishes to express his appreciation of the help, criticisms, and suggestions of B. T. Sweely.

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DISCUSSION ON "SPECIFIC HEATS AND THERMAL REACTIONS OF CLAYS, ETC."[1]

By Willi M. Cohn

ABSTRACT

Due to variation in specific heats obtained by Cohn and MacGee, a criticism and comparison of the results is set forth by Cohn. Methods of determination of specific heat, accuracy claimed for the methods, erroneous assumptions, and several other items are taken up in detail in the fourteen sections of the discussion. The reply by MacGee takes up in detail each of the points raised.

In connection with the work of W. M. Cohn[2] as well as that of A. E. MacGee[3] several points of view are developed for the determination of specific heats and thermal reactions of ceramic materials and the results of the two workers are criticized and compared with each other.

1. The most accurate method for the determination of specific heats of solid substances is doubtless the determination of temperature-heat curves by means of a calorimeter. The substance heated to a definite temperature falls into a calorimeter filled with a liquid, and thus a temperature-heat curve is determined in a number of points from which the specific heats are calculated. Heyn, Bauer, and Wetzel[4] as well as White[5] employed this method.

With this method as a basis, both Cohn and MacGee have developed a process which yields values equivalent to those obtained by this method. Cohn employed as a basis for his work the values and materials of Heyn, and MacGee employed those of White.

2. In stating the average specific heats of ceramic materials, it is preferable to give values between room temperatures, *i. e.*, 20° C and the temperature in question. The stating of average specific heats between 0° C and t° C is not to be recommended from purely practical grounds. This equally applies for the heat necessary to attain a definite temperature, t°C; a reference temperature of 20°C is desired. This is to be recommended for practical purposes so that the specific heats and quantities of heat be given in intervals of 100°C and not be allowed to fall by chance at intermediate values as MacGee did.

3. As to the accuracy of the measurements, Cohn[2] gives $\pm 3\%$; it is limited owing to the error of observation, valuation, and combination

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[1] Translated by A. E. MacGee.

[2] W. M. Cohn, "The Problem of Heat Economy in Ceramic Industry." *Jour. Amer. Ceram. Soc.*, **7**, 359–76, 475–88, 548–62 (1924); *Ber. deut. keram. Ges.*, **4**, 55–67 (1923).

[3] A. E. MacGee "The Heat Required to Fire Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **9**, 206–47 (1926).

[4] "Untersuchungen über die Wärmeleitfähigkeit feuerfester Baustoffe," *Mitt. Kgl. Materialprüfungsamt*, Heft 2–3 (1914).

[5] "Specific Heats of Silicates and Platinum," *Amer. Jour. Sci.*, **28** (1909).

of the curves. MacGee gives the accuracy of his values as being within 10%; for example, it is not possible for him to quantitatively ascertain such reactions as the transformation of α to β quartz, while it is possible to do so by the method of the author. Accordingly it seems that MacGee's assumption[1] that his method is more accurate than that of the author's is not sufficiently proved.

4. The following is to be noted concerning the weight of the substance being investigated; according to MacGee's idea the weight of the substance has no effect on the quantitative size of the reaction within definite limits; however, this idea dares to contradict the views of the classical physicist, *viz.*: The reaction takes place in each part of a definite mass; the sum of the individual reactions gives the size of the reaction taking place, which is measured by our methods.

5. As MacGee has pointed out, it must be admitted that theoretically there is a possibility of only a "limited oxidation" in the case of the experiments of the author. However, in reality the air inside the furnace can readily enter the inside of the crucible through the loosely rod-rolled substance as well as through the pores of the same. This is especially true because of the smallness of the crucible employed, since this had only a diameter of 10 and a heighth of 20 mm and the thermoelement for the measurement of temperature and thermal reactions was in the center of either mass. Therefore, it is hardly likely that there is an error due to incomplete oxidation or the character of the reaction.

6. The equations, by help of which MacGee determined the specific heats are:

$$C_1 = S_1 \cdot t_1 \cdot m_1$$
$$C_2 = S_2 \cdot t_2 \cdot m_2,$$

in which C is the number of calories added, S, the specific heat, t, the temperature rise, and m, the mass of the substance. Aside from the fact that the duration of the action should be contained in the formula I might make the following remarks.

The procedure of MacGee is such that two ceramic materials, the specific heat of one being known while the specific heat of the other substance is to be determined, are placed in a furnace in which the heating takes place. The furnace is so constructed that air readily enters the inside through a great number of perforations provided for this purpose in order that there will be a complete oxidation of the substance.

When the heating of the furnace begins, the following process takes place: the heat is supplied from the furnace walls and heats the air within the furnace. Whereas according to my procedure a uniform

[1] *Loc. cit.*, p. 215.

temperature in which the crucible with the sample was placed was obtained in the furnace only with special precautions, in the case of MacGee's method a stream of air flows into the furnace absolutely uncontrolled. Thus the heat arising from the furnace walls is carried away to a great extent and indeed to all parts of the furnace in different amounts; the accuracy of the experimental results is hereby essentially influenced.

7. The quantity of heat which is given to the sample depends, according to the work of the author as well as other authors, upon the temperature of the furnace walls and the temperature difference between the furnace walls and the sample.[1] The latter value, according to MacGee, can even amount to more than 100°C.[2]

If now, as in the case of MacGee, the weight of the substance contained in the crucibles is different and they are to be compared one with the other (he employed 2.25 grams of quartz and 1.15 grams of sample) there is also a different temperature difference between the furnace walls and the two crucibles of material. Of course the quantity of heat added to the sample and reference material is different. Also the temperature equilibrium within the furnace must hereby be disturbed. Thus the equation ($C = S_1 \cdot t_1 \cdot m_1 = S_2 \cdot t_2 \cdot m_2$) of MacGee is not filled.

There is the natural error which arises through disregarding the different values for the thermal conductivity of different materials, it being all the greater because of the difference in the weights of the samples. In the case of equal weights the error can be disregarded as happens to be the case in the work of the author.

8. The materials employed by MacGee were dried at a temperature of 65° C. The question which arises, is whether all of the physical water contained in the substance is driven off at this temperature. Hence the possibility exists that the temperature-heat curve of the material is so disturbed as to influence the interpretation of the curve.

9. MacGee employed quartz as a reference material. However, as is known, quartz suffers the following changes in the temperature range of 0 to 1400° C; at 575° C the transformation of α to β quartz takes place, while at higher temperatures the formation of tridymite appears. According to the work of the author, the value of the thermal reaction at 575° C is $4.2 \pm .2$ cal./g. for Norwegian quartz and $4.1 \pm .1$ cal./g. for rose quartz. These values are in good agreement with the value, $4.3 \pm .1$ cal./g. found by White.[3] The intensity of the thermal reaction in the case of

[1] *Loc. cit.*, p. 368.

[2] *Loc. cit.*, p. 222.

[3] Wright and Larson, "Quartz as a Geological Thermometer," *Amer. Jour. Sci.*, **27** (1909); *Zeits. f. anorg. Chem.*, **68** (1910).

the formation of tridymite cannot be determined by the author[1] since the process is extended over so long a period. In the curve MacGee gave for the specific heat of quartz according to the values of White, the uniform course of the specific heat at 575° C is seen and this may be the reason why White[2] has not mentioned the specific heats in the neighborhood of 575° C for the majority of his experimental materials.

It seems therefore that quartz is not suitable as a reference material in such a comparison method, since because of its easy transformation the measurements with the reference substance can be disturbed.

In the case of Satoh[3] who likewise employed quartz as a reference material, this source of error appeared and greatly influenced the accuracy of his measurements; a criticism of his measurements is given by the author.[4]

In this connection it is interesting to observe that the values obtained by MacGee[5] for rose quartz agree with those of the author. The reason for this is that MacGee in the case of this experiment employed two similar substances, namely quartz, and thus neutralized the error.

From the above reasons the author thought it correct to select a reference substance which undergoes no transformations within the heating range employed and, therefore, employed a grog as reference material for his experiments.

10. While in all former investigations on the specific heat of ceramic materials values were found which were from about .2 to .3, considerably higher values were given in the case of the investigation of Navias.[6] With regard to a criticism of these values, I may refer to the work of MacGee.[7] MacGee also found values which are considerably higher than previous measurements.

11. According to the results of the experiments of the author the specific heats of the unfired materials are given throughout as lower than the specific heat of the fired material. This behavior is in agreement with the Vant Hoff-Thompson rule, whereby the modification stable at the lower temperature has a lower specific heat than the modification stable at the higher temperature. This rule holds only so long as no thermal reactions take place in the substance. These reactions must affect the specific heat of the substance. In opposition to this,

[1] *Loc. cit.*, p. 485.

[2] *Amer. Jour. Sci.*, **47**, 1–43, (1919); *ibid.*, **28**, 334 (1909).

[3] "Study of the Heating and Cooling Curves of Japanese Kaolinite," *Jour. Amer. Ceram. Soc.*, **4**, 182–94 (1921).

[4] *Loc. cit.*, p. 362.

[5] *Loc. cit.*

[6] "Measurement of the Heat Absorbed and Evolved by Clays during Firing and Cooling," *Jour. Amer. Ceram. Soc.*, **6**, 1268–98 (1923).

[7] *Loc. cit.*, p. 214.

MacGee found that the specific heat of the unfired material was higher than that of the fired. We may assume that these results are due to "errors" of his procedure.

TABLE I

AVERAGE SPECIFIC HEATS BETWEEN 20°C AND t°C

	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400°C
Zettlitz kaolin	.201	.203	.213	.226	.249	.415	.430	.426	.438	.429	.421	.414	.410	.406
China clay	.200	.202	.213	.226	.248	.416	.438	.424	.439	.430	.421	.416	.411	.407
Amorphous alumina	.199	.202	.216	.227	.240	.250	.258	.268	.278	.305				
Commercial corundum	.203	.211	.223	.231	.248	.251	.259	.272	.287	.304				
Sillimanite	.161	.161	.163	.167	.170	.173	.174	.175	.174	.175	.196	.199	.203	.205
Feldspar	.161	.162	.168	.179	.191	.202	.211	.222	.229	.246	.260	.262		
Norwegian quartz	.190	.206	.217	.228	.239	.256	.257	.260	.263	.267				
Rose quartz	.190	.205	.215	.336	.239	.256	.257	.259	.262	.267				
Hohenbocka sand	.190	.205	.214	.223	.233	.251	.254	.257	.262	.267				
Amorphous silicic acid	.214	.224	.236	.246	.254	.260	.265	.269	.272	.277				
Cristobalite	.194	.212	.237	.238	.244	.248	.252	.257	.261	.266				
Chalcedony	.167	.172	.175	.177	.185	.189	.193	.198	.203	.210	.218			
Raw porcelain	.185	.187	.197	.213	.228	.332	.324	.318	.325	.338	.352	.363	.373	.382
Fired porcelain	.189	.195	.203	.212	.222	.232	.245	.264	.287	.304	.337			
Raw porcelain glaze	.170	.174	.183	.193	.208	.246	.239	.259	.278	.280	.291	.299	.307	.292
Fired porcelain glaze	.179	.181	.189	.197	.199	.202	.204	.211	.218	.230	.245			
Raw stoneware	.181	.183	.198	.201	.215	.291	.288	.280	.281	.290	.311	.328	.344	
Fired stoneware	.186	.192	.203	.212	.223	.234	.275	.286	.296	.307	.324			
Raw Halle clay	.189	.195	.211	.223	.247	.349	.345	.331	.323	.344	.359	.368		
Raw grog clay	.191	.194	.201	.211	.232	.347	.332	.311	.322	.343	.365	.384	.401	.414
Fired grog clay	.197	.202	.213	.220	.231	.238	.244	.251	.260	.277	.288			
Fired grog "BC"	.199	.215	.227	.233	.239	.243	.248	.252	.258	.261	.264	.267	.271	.274

For comparison a table, which is more complete than that in the former work of the author, is given above for the materials investigated by the author. The specific heats are also given beyond which thermal reactions occurred and which therefore are quite large.

12. From the curves which give the quantity of heat for the individual substances in cal./g. as related to temperatures, MacGee as well as the author establishes the size of the thermal reaction through tangents drawn to the curve. Although the curves given by both authors are quite similar, there is great variation in the thermal reactions quantitatively. The reason for this is as follows: MacGee assumes that the endothermal reaction in the case of china clay begins at 200° C and draws a tangent to the curve from this point. It can be seen from the curve given by him[1] that it is very difficult to draw an exact tangent from this point because the curve is very flat. The least displacement in the position of the lower tangent gives a considerable difference in the size of the thermal reaction. For this reason the author has taken the correct location of the lower tangent to lie at the point on the curve in which there is a sharp deviation from the original direction owing to the appearance of an intense thermal reaction. Thus, the author's

[1] *Loc. cit.*, p. 234, Fig. 9.

values for the thermal reactions are almost always lower than those of MacGee.

13. As far as the exothermic process at about 900° C is concerned, it was necessary for MacGee to make his extrapolations from only a few points on the temperature-calory curve. In the case of the differential method employed by the author, about 22 measurements were made in the temperature interval of the exothermic process in question and thus the location of the loop was definitely determined. Indeed it appears from theoretical considerations that the appearance of breaks in an otherwise continuous curve is scarcely to be considered.

14. Furthermore it is not clear upon what ground MacGee[1] bases his manner of extrapolating the temperature-calory curve. For example he finds a value of 572 cal./g. at 1100° C. However, from his tables of specific heats and total heat required, he only took the extrapolated value of 543 cal./g. as a basis. According to the opinion of the author, the experiment shows that 572 cal./g. are actually necessary in order to heat a kaolin of the kind investigated to 1100° C, completely independent of the part played by chemical or physical processes taking place. However, it should be noted here that according to the experiments of the author only 455 cal./g. were required in the case of a similar kaolin for attaining a temperature of 1100° C from a starting temperature of 20° C. However, this has nothing to do with the principal question, namely, the evaluation of the curve. The numerical differences in the experimental results are attributed by the author to the above described "errors" in the experiments of MacGee.

It might be briefly summarized that MacGee's conclusion to the effect that the kilns of the ceramic industry are in general more efficient than formerly assumed at least appears to be premature. The high specific heat values can be attributed to the procedure he employed.

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Relating to Specific Heats and Thermal Reactions of Clays

(REPLY TO DISCUSSION BY W. COHN)

BY A. ERNEST MACGEE

The question of specific heats and thermal reactions of clays has been quite ably discussed by Cohn, especially the criticism and comparison of the methods employed and data obtained by himself and MacGee. However, a number of assertions and generalizations have been made which are not in accord with the ideas of the author and which may be

[1] *Loc. cit.*, p. 234.

satisfactorily interpreted in a manner entirely different from that presented.

1. The most accurate method for the determination of interval specific heats of materials which undergo no irreversible thermal changes is, doubtless, the determination of temperature-heat curves by the method of mixtures. Obviously, this method is not suited for determining specific heat values for unfired clays, shales, etc. The most accurate method for determining interval specific heats of materials such as clays which undergo irreversible thermal changes is, in all probability, some modification of the calorimetric method, namely: a method somewhat similar to that employed by Navias.[1]

2. The author sees no urgent reason for giving values between room or factory temperatures, that is 20°C and t°C, rather than between 0 and t° C. In general, 20° C will not be room or factory temperature so that if accurate values are desired a corresponding correction must be made for the variation of the temperature from 20° C. Obviously, this correction is as easily made from 0°C as from 25°C. Furthermore no especial significance is attached to stating the specific heat values in intervals of 100°C but, as it has been suggested from purely practical grounds, the author did express the calories required to heat the various materials in intervals of 100°C.

3. The author believes that the calorimetric method as employed by Navias is the most accurate which has thus far been developed for determining specific heats of pure clays such as A-1 English china clay. Navias assumed that this method yielded values which were accurate to within about 10%. Accordingly, the author hesitated to say that the accuracy of the values yielded by his method were greater than 10% and he does not see wherein Cohn's values are more accurate than those obtained by the calorimetric method. Of course the accuracy of a method is often a matter of opinion and may be assumed to be 3, 6, or 15%, or what not. As a matter of fact, all of the data thus far obtained may vary as much as 25% from the absolute values. However, the author feels that no such inaccuracy exists because of the excellent manner in which the data fit into that which had been previously obtained in heat balances on commercial kilns.

4. The author is of the opinion that the weight of the substance within definite limits has no effect on the intensity of a reaction and he does not think that this view contradicts any established law. Assume that one is measuring the temperature of combustion of coal by means of a large thermocouple. It is easily conceivable that if a very small sample is being fired a large portion of the heat is conducted away by

[1] L. Navias, "Measurement of the Heat Absorbed and Evolved by Clays during Firing and Cooling," *Jour. Amer. Ceram. Soc.*, **6**, 1268 (1923).

the thermocouple or otherwise dissipated so that a temperature far below the theoretical is indicated. As the quantity of sample is increased proportionately less heat is dissipated and higher temperatures are recorded until the temperature of the combustion of the coal is attained. After sufficient sample is employed to compensate for all heat losses, the same temperature is attained regardless of the amount of coal present. It seems plausible to apply this same line of reasoning to thermal reactions appearing in a clay or other ceramic material.

5. The furnace employed by the author was designed to permit of a slow and uniform introduction of air into the space surrounding the specimens by allowing the air to diffuse through a porous furnace core. However, there proved to be sufficient air within the furnace to oxidize the specimens employed so that no additional air was introduced into the furnace. Therefore, the temperature within the furnace was not influenced by an uncontrolled flow of air into the furnace.

6. The author frankly admitted the assumption that since both samples occupy the same volume in a uniform temperature area they will each receive the same heat treatment and will, therefore, attain temperatures which are dependent upon their relative masses and specific heats, to be more or less arbitrary. It was fully realized that the quantity of heat added to each sample was not always exactly the same and that the conditions required by the equation $C = S_1 \times t_1 \times m_1 = S_2 \times t_2 \times m_2$, were not perfectly fulfilled. Also, it was known that disregarding the different values for the thermal conductivity of different materials introduced an additional error. The thermal conductivities of the several materials tested were not known but they were assumed to be not widely different. In this connection, the author might add that the weight of sample employed and the different thermal conductivities also introduced errors into Cohn's determinations. These factors and others are more fully discussed in the original article.[1]

7. The author does not claim that all of the physical water contained in the specimens was driven off at 65° C. This drying temperature was adopted because of its approximating factory drying temperatures. Thus the values are more readily interpreted in terms of factory conditions. Of course more heat is required in the case of a clay dried at 65° C than in that of one dried at 110° C, this being evidenced by a larger endothermic process.

8. The use of quartz as a reference material does not introduce an appreciable error on account of allotropic transformations because these thermal processes are reversible and are accounted for in the

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[1] A. Ernest MacGee, "The Heat Required to Fire Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, 9, 206 (1926).

specific heat values obtained by the method of mixtures. Thus, the specific heat values of quartz included the values for the thermal processes and they are, correspondingly, translatable in terms of the values obtained by the author. A fresh quartz sample was used for each material so that errors due to its inversion into tridymite and cristobalite seem unlikely.

9. Although most of the water which a clay contains is driven off between 500 and 650° C it is generally accepted that some water is evolved over the entire temperature interval, from room temperature to about 650°C. Heat is, of course, absorbed in this process. Therefore, it is to be expected that the specific heat of an air-dried clay will be greater over the interval 0 to 300°C than the fired material. It is to be recalled that Navias and the author found higher values over the lower temperature intervals for the unfired clays than for the fired clays, while Cohn found lower values.

10. The author assumed that the endothermic reaction in the case of china clay began at about 200° C and drew a tangent to the curve from this point. In all probability the endothermic reaction actually began at about 65° C but it was not of sufficient magnitude to cause an upward trend in the calory-temperature curve until about 200° C was attained. It is true that there is a sharp deviation from the original direction of the curve at about 500°C, the endothermic reaction reaching its greatest intensity between this temperature and about 600° C. If tangents were drawn to the curve from these points, a much smaller value for the endothermic reaction would be obtained than if the tangents were drawn from the points represented by about 200 and 625° C. But this value would represent only a portion of the heat absorbed and would in no manner indicate the entire endothermic process which begins at a temperature as low or lower than 100° C. By drawing the tangents at the appropriate points, the value of the endothermic reaction between any two temperatures may be obtained. Of course the author's values are higher than those of Cohn because about 200° C was taken as the point from which the lower tangent was drawn, thus practically all of the endothermic reaction is included in his values.

11. In the case of the exothermic reaction at about 950° C it was necessary for the author to draw the curves from only a few points. It would have been desirable if more measurements could have been made in this temperature interval but the author feels that the extrapolated values for the exothermic reactions are in harmony with the general accuracy of the methods employed for making this type of measurement. This exothermic reaction is quite violent in many cases and is completed in a comparatively short time. Therefore, it seems that a break in the curve is to be expected.

12. When the exothermic process occurred, the sample became much hotter than the furnace although the furnace temperature continued to rise at its usual rate. If the apparatus had been so arranged that the furnace temperatures could have kept pace with that of the sample, no heat would have been lost to the furnace and the calory-temperature curve would have resumed its normal curvature at the point representing the temperature attained by the sample at the termination of the exothermic reaction. Thus for all temperatures beyond the exothermic reaction, it is necessary to extrapolate the curves from the points at which the sample begins to apparently lose heat to the furnace, namely, at the termination of the exothermic reaction.

Summary

In summing up, the author feels that, regardless of the relative accuracy of the interval specific heat values as determined by Cohn, Navias, and himself, his conclusion that the kilns of the ceramic industry are in general more efficient than formerly assumed is not premature. This conclusion is substantiated not only by his results but by practically all of the results obtained by other investigators in this field. It is a well-established fact that practically all clays lose water on heating, an endothermic process of considerable magnitude, and, obviously, require more calories to heat them in the green state to 1000° C than in the fired state. The old specific heat values, from which the calories were calculated, were determined by the methods which did not account for this heat absorbing process. Therefore, specific heat values were obtained which were too low and kiln efficiencies were calculated which were in turn too low.

A STUDY OF SOME FACTORY PROCESSES[1]

By Hobart M. Kraner and E. H. Fritz

ABSTRACT

This paper deals with some ceramic plant methods and machine design which are either wasteful of labor or power. The following are discussed and in some cases actual examples existing were subjected to calculation of the waste involved. Some of these cases remedied were: (1) raw material handling, (2) small power plant costs: boiler practice and plant power factor, (3) screens, (4) steam pipes, (5) heat insulation, (6) steam jets, (7) sagger presses, and (8) steel dies.

A recent survey[2] has revealed the fact that the ceramic industry uses science to the extent of only 12% in its present operation. Perhaps one reason for this is the fact that much of the industry depends upon craftsmanship and traditional information. This no doubt applies also to the engineering involved in the plants as well as to the design of machinery employed, for among the latter we find many monstrosities. Fortunately, however, more attention is now being paid to this matter due largely to the increasing appreciation of power costs.

In several whiteware plants coming within notice of the writers some glaring examples of poor engineering were found to exist and seem worthy of analysis. They are examples no doubt very similar to those existing in many other plants, and although they do not go unnoticed by those in charge, they are costly and their elimination in most cases would pay good dividends on the investment. Perhaps in many cases funds are not available to replace obsolete machinery and the management finds it necessary to futilely proceed with such equipment.

With all of this in mind, however, it seems proper to point out such glaring examples of waste in these plants which are of the "small plant" variety.

Raw Materials

The method of unloading raw ceramic materials is usually crude, due perhaps to the very nature of the materials. It is done in as many ways as there are ceramic plants. Costs of unloading amount to as much as 85 cents per ton, adding in this latter case between 5 and 10% to the cost of the raw material received at the plant.

Figure 1 shows a bin arrangement where the unloading cost was 34 cents per ton and an additional 14 cents per ton was required to move the materials away from the window through which it had been shoveled. The raw materials received in the 10 bins amounted to 16,000 tons annually, resulting in an expenditure of $2240 inside the

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (White Wares Division.)

[2] "Petroleum Development and Technology in 1925," *Trans. Amer. Inst. Mining Met. Eng.*, p. 721.

bins exclusive of shoveling through the windows into the bins. Simple labor saving equipment, such as indicated in Figure 2, entirely replaced the labor required in the bin.

Figure 3 is another example of costly clay unloading at 85 cents per ton. Here the clay is piled high in the bin, necessitating considerable hand labor in addition to the usual transfer of the material from the car to the edge of the bin which, in this case, is done by means of chute and wheelbarrow. This excessive handling could easily be obviated as indicated in Fig. 4. A screw conveyer is not so suitable, however, for ball clays unless they are pulverized, where possible, at the car. Other types of conveyers are available which would easily handle such material.

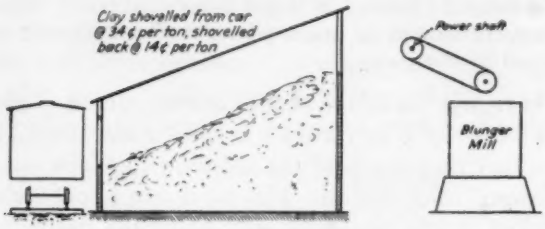

FIG. 1.—Present method of handling cars.

Figures 5 and 6 show a modern unloading conveyer system which not only conveys the materials from the cars to the bins, but distributes them in the bins as hand labor could not do. It permits an even spreading of the materials over the entire bin one car load upon the other until full to the top. Then when the bin is unloaded these binsful of materials are cut vertically so as to obtain material which is representative of a number of cars. The same conveyer carries this material to the loading hopper immediately above the scales. This method shows 40% unloading cost reduction for ball clay, 11% on flint and feldspar, and 25% on china clay. This reduction is not large but since the conveyers eliminate the labor required to distribute the materials in the bins and convey them to the hopper, these reductions in car unloading costs are not the only benefits derived.

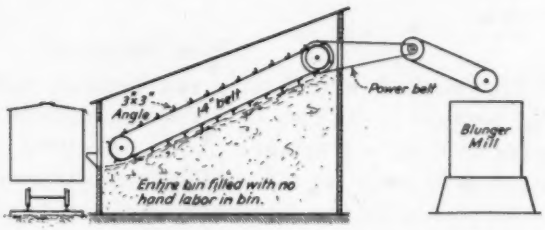

FIG. 2.—Proposed method to eliminate labor in bins.

Figure 7 is another modern arrangement for raw material unloading which eliminates considerable hand labor.

Power Plants

In small power plants such as might be found in average sized ceramic plants the efficiency is low due to the size of the unit. In addition, the practices are usually poor due to the character of the personnel.

Gephart[1] makes the general statement that every 10°F increase in temperature of boiler feed water which is fed into a boiler results in 1% fuel saving (see Table I). In one of these plants feed water was being used at room temperature, approximately 70°F. By proper use of the feed water heater available and with exhaust steam which was otherwise being wasted, this temperature was raised to 205°F, a

TABLE I

PERCENTAGE OF SAVING FOR EACH DEGREE OF INCREASE IN TEMPERATURE OF FEED WATER

(Based on Marks & Davis Steam Tables.)

Initial Temp. of Feed	Boiler Pressure above Atmosphere										
	0	20	40	60	80	100	120	140	160	180	200
32	.0869	.0857	.0851	.0846	.0843	.0841	.0839	.0837	.0835	.0834	.0834
40	.0875	.0863	.0856	.0853	.0849	.0846	.0845	.0843	.0841	.0840	.0839
50	.0883	.0871	.0864	.0859	.0856	.0853	.0852	.0850	.0848	.0847	.0846
60	.0891	.0878	.0871	.0867	.0864	.0861	.0859	.0857	.0855	.0854	.0853
70	.0899	.0886	.0879	.0874	.0871	.0868	.0867	.0865	.0863	.0862	.0861
80	.0907	.0894	.0887	.0882	.0878	.0876	.0874	.0872	.0871	.0870	.0869
90	.0915	.0902	.0895	.0890	.0887	.0884	.0882	.0880	.0878	.0877	.0876
100	.0924	.0910	.0903	.0898	.0895	.0892	.0890	.0888	.0886	.0885	.0884
110	.0932	.0919	.0911	.0906	.0903	.0900	.0998	.0896	.0894	.0893	.0892
120	.0941	.0927	.0919	.0915	.0911	.0908	.0906	.0904	.0902	.0901	.0900
130	.0950	.0936	.0928	.0923	.0919	.0916	.0915	.0912	.0911	.0910	.0909
140	.0959	.0945	.0937	.0931	.0928	.0925	.0923	.0921	.0919	.0918	.0917
150	.0969	.0954	.0946	.0940	.0987	.0933	.0931	.0930	.0928	.0927	.0926
160	.0978	.0963	.0955	.0948	.0946	.0942	.0940	.0938	.0936	.0935	.0934
170	.0988	.0972	.0964	.0958	.0955	.0951	.0948	.0947	.0945	.0944	.0943
180	.0998	.0982	.0973	.0968	.0964	.0960	.0958	.0956	.0954	.0953	.0952
190	.1008	.0992	.0983	.0977	.0973	.0969	.0968	.0965	.0964	.0963	.0962
200	.1018	.1002	.0993	.0987	.0983	.0978	.0977	.0974	.0973	.0972	.0971
210	.1029	.1012	.1003	.0997	.0993	.0989	.0987	.0984	.0983	.0982	.0981
220	....	.1022	.1013	.1007	.1003	.0999	.0997	.0994	.0992	.0991	.0990
230	....	.1032	.1023	.1017	.1013	.1009	.1007	.1004	.1002	.1001	.1000
240	....	.1043	.1034	.1027	.1023	.1019	.1017	.1014	.1012	.1011	.1010
250	....	.1054	.1044	.1008	.1034	.1029	.1027	.1024	.1022	.1021	.1020

Multiply the factor in the table corresponding to any given initial temperature of feed water and boiler pressure by the total rise in feed-water temperature; the product will be the percentage of saving.

probable saving of 13.5% fuel. With coal at $3.00 per ton the saving was approximately $1000 per year.

In some plants the importance of keeping the tubes cleaned is not appreciated, for a boiler being cleaned at one of these plants showed as much as $\frac{3}{8}$-inch hard scale on the tubes. According to tests made at the University of Illinois[2] where the scale accumulation was as much

[1] Steam Power Plant Engineering, p. 884.

[2] See also *Power*, Feb. 1903, p. 70.

as .11 inch, the heat loss was as much as 19%. The heat loss where scale existed to the extent of $\frac{3}{8}$ inch would be difficult to estimate.

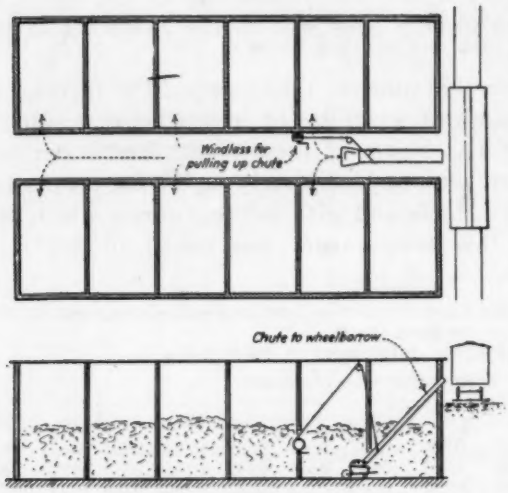

FIG. 3.—Unloading material by chute, wheelbarrow, and shovel.

Practices such as these together with the concurrent low efficiency of small units make power manufacture in small plants a questionably economical practice.

Small plant efficiency is usually 50 to 60%; seldom 75%. Figure 8 would indicate[1] that the average ceramic plant's power plant may show a large variation in cost per horse power as well as this cost being relatively high. If a plant were to buy 100 h.p. at 2.5 cents per kw. hr., the cost per h.p. per year would be $56, a figure below the low figure indicated on this curve for a similar sized plant manufacturing its own power very efficiently. It is not likely that the low power costs indicated on the lower one of these two curves would prevail in plants where the foregoing practices existed (see also Tables II and III).

Steam for driers and plant heating generated at lower pressures and without licensed engineers would have to be supplied where power is bought from the public utility.

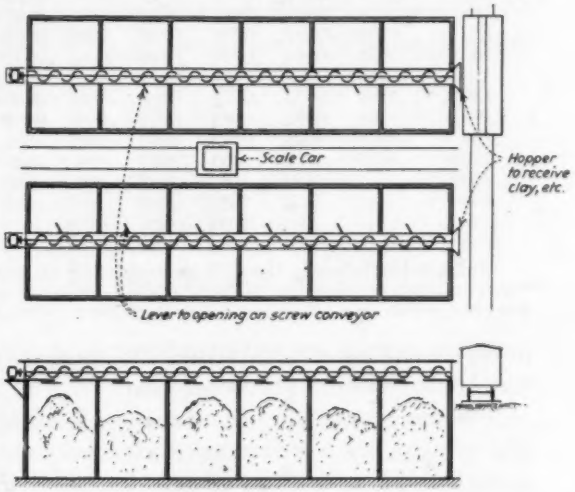

FIG. 4.—Proposed design to reduce unloading cost.

[1] Gephart, *loc. cit.*, p. 884.

TABLE II

COST OF ONE HORSE POWER PER YEAR, SIMPLE ENGINES, NONCONDENSING
10-HOUR BASIS, 308 DAYS PER YEAR.

(Wm. O. Webber, *Engineering Magazine*, July, p. 563, 1908)

Size of plant horse power	20	40	60	80
Cost of plant per horse power	$200.00	$190.00	$180.00	$175.00
Fixed charges at 14 %	28.00	26.60	25.20	24.50
Coal per horse-power hour, in pounds	12.00	10.00	9.00	8.00
Cost at $4.00 per ton	66.00	55.00	49.50	44.00
Attendance, 10-hour basis	30.00	20.00	15.00	13.00
Oil, waste, and supplies	6.00	4.00	3.00	2.60
With coal at $5.00 per ton	146.50	119.35	105.07	95.10
With coal at $4.50 per ton	138.25	112.47	98.80	89.60
With coal at $4.00 per ton	130.00	105.60	92.70	84.10
With coal at $3.50 per ton	121.75	98.72	86.51	78.60
With coal at $3.00 per ton	113.50	91.85	80.32	73.10
With coal at $2.50 per ton	105.25	84.97	74.13	67.60
With coal at $2.00 per ton	97.00	78.10	67.95	62.10

TABLE III

COST OF ONE HORSE POWER PER YEAR, COMPOUND CONDENSING ENGINES.
10-HOUR BASIS, 308 DAYS PER YEAR.

(Wm. O. Webber, *Engineering Magazine*, p. 564, July, 1908)

Size of plant horse power	100	200	300	400	500	600
Cost of plant per horse power	$170.00	$146.00	$126.00	$110.00	$96.00	$85.00
Fixed charges at 14 %	23.80	24.40	17.65	15.40	13.45	11.90
Coal per horse-power hour, pounds	7.0	6.5	6.0	5.5	5.0	4.5
Cost of fuel at $4.00 per ton	38.50	35.70	33.00	32.00	27.50	24.70
Attendance, 10-hour basis	12.00	10.00	8.60	7.25	6.20	5.40
Oil, waste, supplies	2.40	2.00	1.72	1.45	1.24	1.08
Total	76.70	68.10	60.97	56.10	48.39	43.08
With coal at $5.00 per ton	86.40	77.10	69.22	61.90	55.29	49.28
With coal at $4.50 per ton	81.50	72.60	65.07	58.10	51.79	46.18
With coal at $4.00 per ton	76.70	68.10	60.97	56.10	48.39	43.08
With coal at $3.50 per ton	71.90	63.70	56.82	50.50	45.04	30.98
With coal at $3.00 per ton	67.00	59.20	51.67	46.70	41.49	36.88
With coal at $2.50 per ton	62.30	54.75	48.59	43.00	38.83	33.83
With coal at $2.00 per ton	57.45	50.25	44.47	40.10	34.64	30.73

Size of plant horse power	700	800	900	1000	1500	2000
Cost of plant per horse power	$76.00	$69.00	$64.00	$60.00	$58.00	$56.00
Fixed charges at 14 %	10.65	9.65	8.95	8.40	8.12	7.85
Coal per horse-power hour, pounds	4.0	3.5	3.0	2.5	2.0	1.5
Cost of fuel at $4.00 per ton	22.00	19.20	16.50	13.75	11.00	8.25
Attendance, 10-hour basis	4.70	4.15	3.75	3.50	3.25	3.00
Oil, waste, supplies	0.94	0.83	0.75	0.70	0.65	0.60
Total	38.29	33.83	29.95	26.35	23.02	19.70
With coal at $5.00 per ton	43.79	39.73	34.05	29.80	25.77	21.75
With coal at $4.50 per ton	41.04	36.28	32.00	28.05	24.39	20.72
With coal at $4.00 per ton	38.29	33.83	29.95	26.35	23.02	19.70
With coal at $3.50 per ton	35.54	31.48	27.87	24.60	21.64	18.67
With coal at $3.00 per ton	32.79	29.03	25.80	22.90	20.27	17.65
With coal at $2.50 per ton	30.04	27.18	23.75	21.20	18.89	16.60
With coal at $2.00 per ton	27.29	24.23	21.70	19.47	17.52	15.57

Power Factor

This is a subject which is not appreciated as much by plant executives as it should be. Their usual consideration is in the extreme of continuous operation. The greatest consideration is for "ample power." The usual result is underloaded motors and consequent low power factor with higher power costs than should be.

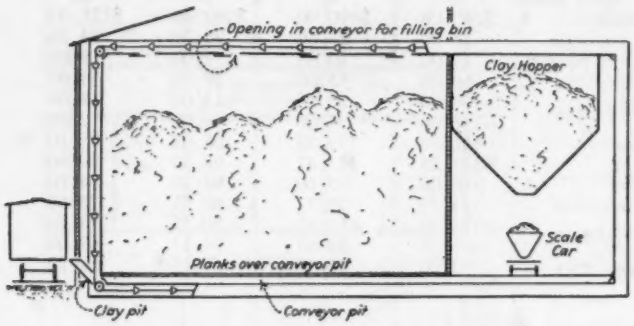

FIG. 5.—Modern clay bin using minimum loading.

There are two kinds of current flowing in the lines of a plant: (*a*) magnetizing current and, (*b*) running current. Running current is useful whereas the magnetizing current is a necessary evil which should not exist in too large a proportion. Power factor may be roughly expressed as the ratio of useful or running current to the total current. If the factor is low, the equipment necessarily carried to produce this excess magnetizing current must be paid for by the consumer. If the producer is a large power plant it is paid for in demand charges and power factor fines. If the consumer produces his own power he is probably running a generator much larger than would be necessary were his power factor higher.

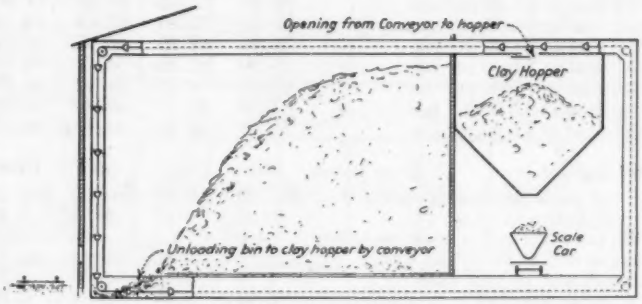

FIG. 6.—Modern clay bin using minimum unloading labor.

The losses are largely heat losses in the factory lines. An example of this loss to the consumer-producer would be in the following: A plant's power factor is 40%. Two generators and two engines are necessary to carry the load. If this power factor is increased to 80% one generator and one engine would carry the load. This is particularly important where the power

equipment is running at its maximum capacity and the advisability or necessity of increasing power plant equipment is being considered.[1]

A change of motors to greater loading, the use of static condenser equipment, specially excited synchronous motors, or synchronous condensers might be used to correct the situation with little expenditure. It is seldom that a power factor is as low as 40%. Power factors of 70 to 80% are average, higher than 85% are generally not produced economically. Power factor conditions between 40 and 70% present possibilities for great economies. For instance, a plant having a power

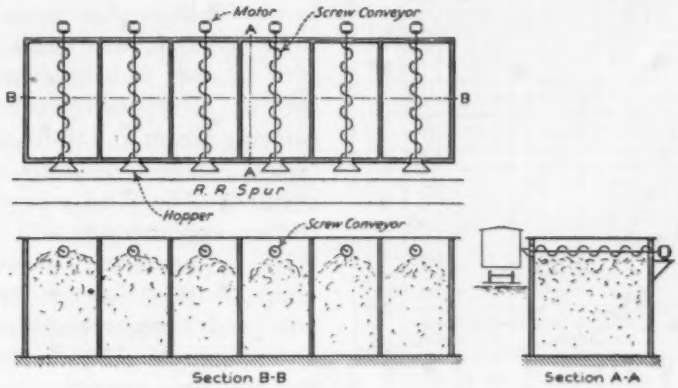

FIG. 7.—Modern bins using no labor during filling.

factor of 50% and with a monthly power bill of $960 reduced this to $796 by an increase of power factor to 70.7. This is a typical example given by Underhill.[2] The annual saving is $1868 and in this case no power factor improvement equipment was necessary. The improvement was made by re-arranging motors in the plant, using them at more nearly their capacities.

The revenue for electrical power in the United States in 1924 was $1,350,000,000. The capital invested in power plants was $6,660,000,000 of which 55.5% was electrical equipment. Assuming a 60% power factor, the idle invested capital was $1,465,000,000 whereas a 90% power factor would reduce this idle or useless equipment to $366,000,000. It is apparent that the consumer must pay for this equipment unless he corrects his power factor. Many of the utilities reduce power rates 5 to 10% with increases in power factor above 70 or 80% and attach fines for power factors below 70%. One company selling power factor corrective equipment in order to enter the market is willing to accept

[1] Synchronous Motor Drive in Brick Plant, *Elec. World*, May 30, p. 1137 (1925).
[2] Underhill, Power Factor Wastes.

these fines, or the reduction in power costs for two years as payment for their power factor corrective equipment. They claim that the equipment is paid for in the first year of service.

Steam Pipes

Steam pipe coverings are often neglected, and yet the losses resulting from uncovered steam pipes as shown in Figure 9 are enormous. According to these curves, 1 square foot of uncovered steam pipe carrying steam at 150 lbs. radiates to the room heat equivalent to 0.1 lb. coal per hour.

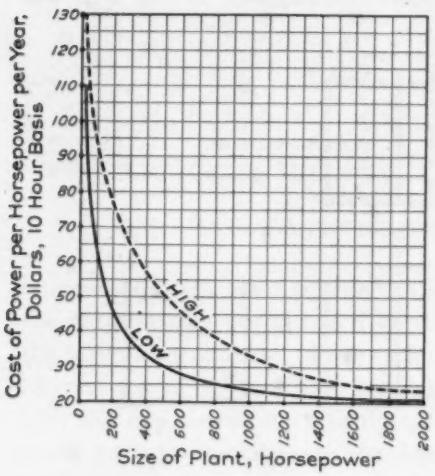

FIG. 8.—Curves showing range in cost of power in 200 manufacturing plants in middle western states.

In one plant there were 100 ft. of 5-inch pipe and 500 ft. of 2½-inch steam pipe carrying steam at 150 lbs. at the boiler. These pipes were all uncovered. The total area of pipe surface exposed was 488 sq. ft. With a conservative average temperature difference between pipe and room temperature of approximately 250°F, the fuel loss for these conditions was 34 lbs. coal per hour or 146 tons per year. The boiler efficiency was 75% or less. The actual fuel loss would be therefore approximately 195 tons, 75% of which could have been prevented by suitable pipe covering. (See Figure 10).

In this one instance other power house practices were poor for the uncovered pipe to the engine delivered very wet steam; pressures at considerable distances from the boilers were unreliable and low. For a long period of time little or no exhaust steam was being utilized for driers or other heat. Much of this was remedied to such an extent that not enough exhaust steam is now available to supply the demand for low pressure lines and high pressure steam must be supplied to fill the want. The fuel saving is notable.

Steam Jets

Another wasteful use of steam is the steam jet for pumping slip, etc. The usual efficiency according to Marks[1] is approximately 1 to 2%. This is for a properly designed steam jet. The relative amount of

[1] Marks, Mechanical Engineers' Handbook, p. 1479.

steam per water h.p. per hr. is 400 lb. for steam jet pump and 100 to 200 for a direct acting steam pump. The case which was so glaring was an inefficient installation of pipe fittings in steam jet pump fashion pumping slip from cisterns to the lawns. The slip returning to the cisterns was heated from the steam used to such an extent that even after filter-pressing the workmen could not handle the filter cakes with their bare hands. This heat represents a loss which could be recovered in an electrically driven or reciprocating steam pump installation when the exhaust steam is returned to the low pressure lines.

Assuming a cistern 10 feet deep filled with slip whose content of solids is approximately 25% and an average lift of slip to the lawn of 6 feet, the power required to do the work of lifting 4 tons of slip per hour (one ton of dry material) would be only $\frac{1}{30}$ h.p.

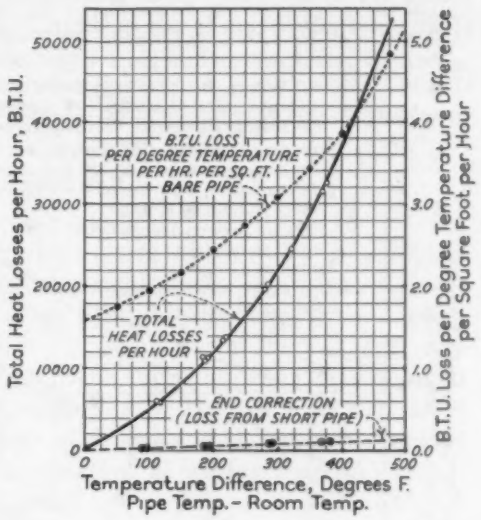

FIG. 9.—Total losses from bare pipe. (15 feet length 5-in. pipe.)

In this instance an improvised, and undoubtedly very inefficient steam jet was the result of the construction used. The efficiency was therefore probably far below the figures, 1 to 2%, as given by Marks for properly designed steam jet pumps. Steam driven plunger pumps and electrically driven pumps give 10 and 6% efficiencies, respectively. In addition to this waste of steam power, heating of the slip to such an extent is obviously not to be recommended.

Screens

An old type of slip house lawn has given nearly everyone using it difficulty in holding it to its foundation. The lawn frame and reciprocating parts weigh 375 pounds. They vibrate at the rate of 300 cycles per minute. Fortunately, a flywheel is used to cut down the peak load at the beginning of the returning stroke. A calculation of the energy required to do this work indicates that such a heavy screen requires 4 h.p. Actual measurements of electrical power are not available to verify this figure, but the question of why such a heavy machine is necessary is not easily answered, for the same work is being done with lighter machines with 1 h.p. and less.

Sagger Presses

An old type of steam sagger press having a 30-inch piston and 24-inch stroke uses a full cylinder of high pressure steam to form a sagger. The actual amount of work necessary to form the sagger is only a small portion of the work contained in such a volume of steam. Where the steam from the press is exhausted into the low pressure lines, this steam cost per sagger is not so large.

A 2-h.p. motor will do this work, yet 3.4 h.p. is required.

There is also a waste through radiation from the cylinder which is seldom insulated. The surface area is 27 sq. ft. and the heat loss is considerable.

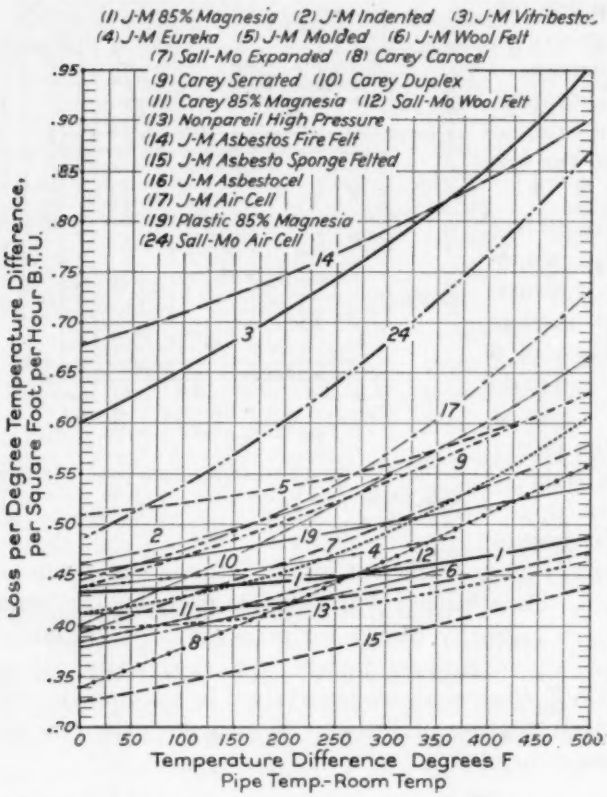
(1) J-M 85% Magnesia (2) J-M Indented (3) J-M Vitribesto
(4) J-M Eureka (5) J-M Molded (6) J-M Wool Felt
(7) Sall-Mo Expanded (8) Carey Carocel
(9) Carey Serrated (10) Carey Duplex
(11) Carey 85% Magnesia (12) Sall-Mo Wool Felt
(13) Nonpareil High Pressure
(14) J-M Asbestos Fire Felt
(15) J-M Asbesto Sponge Felted
(16) J-M Asbestocel
(17) J-M Air Cell
(19) Plastic 85% Magnesia
(24) Sall-Mo Air Cell
Loss per Degree Temperature Difference, per Square Foot per Hour B.T.U.
.95 .90 .85 .80 .75 .70 .65 .60 .55 .50 .45 .40 .35 .30
0 50 100 150 200 250 300 350 400 450 500
Temperature Difference Degrees F
Pipe Temp.-Room Temp

FIG. 10.—Heat loss through pipe covering (single thickness).

Steel Dies

The number of pieces made from an ordinary steel dry press die will be quite variable. Lives as low as 15,000 pieces have been reported. However, as many as 500,000 pieces are reported for special steel dies. With this variation there seems to be a great possibility for die cost reduction per piece of ware especially where large quantities are to be made from the die.

The foregoing, it is hoped, will provide food for thought both to the designer of machinery and those selecting suitable and economical equipment.

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SOME NEW IDEAS IN CLAY WORKING[1]

By H. R. Straight

ABSTRACT

The ideas which the author intends to try out on a plant scale are as follows: (1) roll crushing of the planer product, (2) use of a modernized soaking pit with pug mills, (3) heating pugged clay before molding, (4) air evacuation during pugging, (5) setting ware on kiln cars and running them through a humidity drier at a slow variable rate, (6) use of a wider tunnel kiln, especially for hollow ware, with special circulating features, and (7) mechanical handling of fired ware. Each idea is taken up and discussed in detail; all are along lines of eliminating manual effort, saving fuel, and increasing production per dollar invested.

Introduction

There is a saying among industrial engineers that 90% of the making is moving. There is probably no industry to which this saying applies better than to the manufacturing of clay products. An analysis shows many movements from place to place with comparatively little actually done in processing.

It can be safely said, that there is no industry which has adhered so closely as have the ceramic industries to the old and time-tried methods, the reason being the lack of profits and the resulting lack of opportunity for research and application of engineering in general.

In designing a new plant, the writer has thrown aside precedent and proposes in the near future to try out on a plant scale some of the following ideas.

Crushing Product of Planer

The planer, in shale and hard clay digging, has proved to be a success beyond any reasonable chance of dispute. The planer gives a partial fine preparation to the extent that usually at least 20% is fine enough to go directly into the pugging stage. These fines have never, to the writer's knowledge, been successfully separated out. If this were done there would be a very noticeable increase of efficiency in the crushers because the fines serve as a cushion between the coarser particles during crushing.

The reason that the writer has heretofore failed to bypass these fines before crushing was because some of the planer product was too coarse to be handled successfully with any screen available at that time.

It is now expected that the planed shale will be given a preliminary crushing at the planer before loading by passing through a slugger or single roll crusher which will reduce everything to three-fourths inch

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Heavy Clay Products Division.)

or smaller. This should give a product in which there will be close to 50% of fines ready to go into the pug mill. The result also will be a product which, when brought to the plant, will handle better from a hopper with an apron feeder under the bottom and will be more thoroughly mixed than otherwise would be possible. The feeder can easily have within its reach 1500 tons of storage by going up 40 feet in the air with the tram dump.

The feeder discharge over a shaking or vibrating-screen will bypass out at least 40% of the total, which bypassed fines will of course be suitable for the pugging process.

Experiments have proved that with shales the dry pan does not give the breaking down of grain that rolls give and the final reduction by the rolls gives a greater plasticity with the same water in less time than does the product from the dry pan. Since previous preparation at the planer has reduced everything to three-fourths of an inch and smaller, there is no reason why a set of smooth rolls of large diameter will not reduce everything to one-eighth inch flakes and smaller with less power, fewer repairs, and no recirculating of the load.

No Cup Elevators

The writer's experience has always been more favorable with conveyers than cup elevators in connection with the handling of clay. Since there need be no recirculation of clay in grinding with rolls, an inclined conveyer may be used for the one and only elevation of the ground material to the storage above the pug mill.

Pug Mill

It has always been a well-known fact that we are lacking in the time necessary for water to properly penetrate and uniformly distribute itself into the mass of the clay material. It has also become a well-established fact that where perfect pugging is required, as in the glass pot industry, no substitute has been designed that will entirely replace the old time soak pit.

Why not put the soak pit on wheels and revolve it very slowly so that the clay discharged from the hopper above the center of the pit, or platform, can be slowly worked with water from the center out and at least thirty minutes later discharged over the outer edge on to an inclined conveyer, which will carry it to a machine in which will be added the remainder of the water required.

The usual interval from the time the clay enters the pug mill until it leaves is one to two minutes but, with the method proposed, with a thirty-minute interval, would not the elapsed time do what we are now doing with power in a better way at a saving of cost? Undoubtedly time is cheaper than power.

Heating Pugged Clay before Molding

After the clay has arrived at the mill for molding, it is planned that two unusual treatments will be given it. In laboratory experiments on drying it was found that, under controlled humidity, controlled air circulation, and controlled temperature, approximately three-fourths of the total time for drying was of necessity used in heating the clay. It occurred to the writer that, if this heating could be done before molding, it could be done almost instantly. Therefore, why not force live steam into the partially pugged material to heat it thoroughly throughout before it goes into the augers for molding.

An attempt to design suitable means for this heating will be made. It has been done successfully in the laboratory and the results obtained in drying were really surprising. Whether or not it can be done successfully in a continuous process is yet to be determined.

Air Evacuation

Mr. Spurrier showed results last year, obtained in terra cotta bodies where the air was evacuated from a batch, that were surprising. It will probably not be possible to secure as good results in a continuous process with heavy clays by evacuating the air from the final pugging chamber. However, it is expected that by closing the final pugging chamber and maintaining approximately a 23-inch vacuum while the clay is being agitated and pugged, the body of clay material will be freed of the confined air better than from a stationary mass in a more complete vacuum. An actual trial will probably be necessary to prove which method would give best results.

There will be a desirable effect obtained in eliminating the most of the air pockets which no doubt cause strains in drying and slow up the entire drying process.

Is it not likely that the inert nitrogen in these air pockets, which is left during the firing process, will interfere with oxidization if air is not evacuated?

It is also a well-established fact that these pockets resulting from confined air, which are very commonly called auger lamination, cause failures of the units on freezing and thawing. There has never been any doubt in the mind of the writer but that union of all the interior clay surfaces would be complete under the auger pressure, as the clay passes out of the die, if there were no air present in the clay to collect between interior surfaces as the auger pulls out of the clay; for there is no doubt but that, regardless of pressure applied, it is never possible to unite interior surfaces as long as the air is present. It is really surprising how little power and equipment is required for evacuating the air from a closed chamber above the auger.

Setting Ware on to Drier Cars

After the units have been passed on to the delivery belt from the cutoff, the materials will be delivered to off-bearers standing on movable platforms just clearing the railroad tunnel kiln cars. One-half of the ware will be set from one machine and partially dried before the remainder is set from another machine located higher up and over the cars farther along the line at right angles to the delivery belt. There will be enough tunnels in the drier so that the necessary number of off-bearers will have sufficient work room to properly set the material required by the kilns.

The Drier

When setting is completed, the material is then slowly moved through the driers at the same rate it is being set and, whenever the molding machines are not operating, the drying will continue with the cars stationary. The drying will be done through a humidity drier with a positive circulation downward through the ware on the cars with means for recirculating the air several times from the hot toward the cold end.

The cars will be moved below the off-bearers continuously at a very slow variable rate so that the ware will be moved away only as fast as set and directly into the driers. Space is provided beyond the drier tunnels for the accumulation of dried ware on kiln cars so that during the week sufficient extra material will be manufactured, set, and dried to supply the kiln during the Sunday period of mill shutdown.

The Kiln

By using a vertical circulating system through the ware on the kiln cars while the ware is passing through the kiln, it is expected that a wider kiln than has ever been built will at least work out on hollow ware. This will give a capacity of hollow ware which has, up to this time, prevented the railroad tunnel kiln from being used to any advantage for firing hollow ware. The additional cost of construction because of the kiln being wider will not be great and a much better fuel economy may be expected on account of the less radiation from side wall and arch per square foot of cross-section of the charge passing through.

The major part of the cooling will be done with air passing upward through the ware with the same effect as cooling by backdrafting in the sewer pipe industry. This well known method produces less cooling strains than cooling in any other way for the reason that the cooler spots naturally circulate less air upward because of loss of buoyancy and there is attained a natural balance in cooling at a maximum cooling rate with a resulting uniform annealing effect.

In the combustion zone the flame from the burning oil, gas, or powdered coal will be vertical from a series of burners on each side of the charge passing through this chamber. The flame will be directed upward through a continuous restricted opening along each upper edge of the charge. The increasing velocity, as the flame ascends during combustion, should give an inductive pull on the cooling gases going downward through the ware and through the connecting flues leading to each side in the floor of the cars beneath the ware. The mixture of the hot combustible gases and hot air should give perfect combustion very quickly. The rush of the flame upward through the restrictions will build up from the velocity a pressure head and the static pressure head should cause a flow of combustion gases downward through the vertical channels in the setting of the ware.

The cooling of the products of combustion and excess air in passing downward through the ware will create a small negative pressure head which, together with the static head above and the induction on the sides, will surely cause a continuous and positive recirculating of the gases through the ware passing through the firing zone. It is expected that this will give a more uniform temperature throughout the setting than could be possible to obtain by radiation alone.

In the preheating end of the kiln the major part of the heating will be done by gases passing downward through the ware and the movement will be downward for exactly the same reason that the gases should pass upward through the ware in the cooling end.

It is not generally known that cold spots practically do not exist in downdraft kilns, almost regardless of closer setting in places, for the same reason that it is almost impossible to get rid of cold spots in updraft kilns. Hot gases in passing downward through a cold spot tend to speed up in velocity and the increase in velocity carries more gases through the cold spot and brings the temperature up to equal that of the surrounding ware and the balance in temperature is restored and maintained. If the gases are passing through a cold spot in an updraft kiln which is being heated up, the cold spot is exaggerated on account of the slower movement of the heating gases through the restricted and cooler area. It therefore seems to the writer that a railroad tunnel kiln designed to make use of the principle that has been used for years in standard practice in round kilns should work perfectly.

Stocking of Fired Ware

The ware, after passing out of the kiln, will be transferred to a covered loading bay over which throughout its entire length a traveling crane will be operated. For more than twenty years such cranes for handling brick have been operated in the Chicago yards with

uniform success. There they use two men to guide the fingers of the lift hooks under the brick and the operator above controls the movement of the bridge, carriage, and hoist. The operator receives signals from the men below for the control of the carriage and hoist and his reactions are therefore secondary. Why not place the operator of the entire crane on the back of the hooks with all controls before him, which controls can then be operated under his own reactions the same as any shaft elevator is operated by a man within the cage?

Material after being placed on a suitable rack, in open top cars so that the fingers of the hooks can be backed out from under the ware, will then be repiled and sorted. This will be only the second time in the entire process of manufacturing where manual effort for moving the ware will be used. A comparison with most plants will show that less than one-fifth the number of manual efforts ordinarily used will be required as compared with the older processes. The resulting saving in labor should cut the man hours per ton from an average in the older plants of three to four to about eight-tenths man hours per ton of manufactured ware.

Storage stock will be lifted and placed on suitable masonry racks below an outdoor gantry crane which will be controlled in the same manner as the indoor traveling crane. This storage stock may be reclaimed at any time necessary for loading.

It is not expected that all the ideas proposed will be worked out and placed on a commercial basis, without some changes, but from an engineering standpoint the ideas are at least feasible and are along lines of eliminating manual effort, saving fuel, and increasing production per dollar invested. The result should be a stronger and more uniform ware.

ADEL CLAY PRODUCTS COMPANY
ADEL, IOWA

A CONVENIENT PLATINUM-WOUND RESISTANCE FURNACE[1]

By Edward Orton, Jr. and J. F. Kreebiel

The problem was to produce a furnace with effective hot chamber less than three inches in diameter, by four or five inches in length. The temperature had to be uniform throughout this chamber, the control accurate, the atmosphere clean and oxydizing and able to melt cone 20.

ABSTRACT

Details of construction of the furnace are given including the principal platinum resistor, the two end coils, Chromel booster coil, shell, refractories, insulators, etc., with detailed drawings and photographs. The log and graphs showing the behavior of the furnace in a cone 20 firing (1533°C) at a rate of temperature increase of about 33°C per hour are given. The cost of the furnace, the controlling apparatus, and the temperature measuring equipment, are given in detail.

The furnace meets the requirements successfully, as to performance. Its practical value will depend on the life of the platinum resistor which cannot be foretold. In the thirty-one firings so far completed no changes have been observed in the electric performance or apparent condition of the furnace. Its performance at the end of the first year's operation will be given in a subsequent paper.

I. General Review of Case

In the early part of 1924, at the request of the Research Committee of the Refractories Division of the American Ceramic Society, the United States Bureau of Standards made a careful study of the temperature equivalents of the pyrometric cones in use in this country. They recognized that the cone temperature equivalents must be dealt with *de facto*, and not as a question of abstract desirability. A representative group of consumers as well as the American producers was organized as an Advisory Committee, in order that the Bureau's findings might be accepted as having been reached in a judicial manner.

Equipment Used by the Bureau

The equipment used by the Bureau, in that portion of its work which was executed by the Department of Temperature Measurements is described in its Report.[2] The two furnaces, one heated by a Chromel coil, and the other by a spiral graphite coil, were reproduced accurately, set up by the present writers, and put into operation in the fall of 1925.

II. The Chromel-Resistor Furnace

The Chromel furnace, as built by the Bureau is an excellent tool, accurately controllable, durable, inexpensive to build and operate, giving practically black-body conditions, with very low temperature gradients in the test chamber. Its sole limitation is its low maximum temperature, practically 1200°C.

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[1]Presented at the Annual Meeting, American Ceramic Society, February, 1927, Detroit, Mich. (Heavy Clay Products Division.)

[2] C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *Jour. Amer. Ceram. Soc.*, 9 [11], 701–43 (1926).

III. The Graphite Resistor Furnace

The experience of the Bureau of Standards with the carbon resistance furnace amply demonstrates that the furnace designed by the Bureau can be pushed up to very elevated temperatures (cone 38 in one instance) though always at a heavy cost in wear and tear. When operated at moderate temperatures (1100–1500°C), its life is much better, though not what could be called good, when viewed as a commercial tool, where cost of maintenance, reliability, and infrequent interruption for repairs are vital factors.

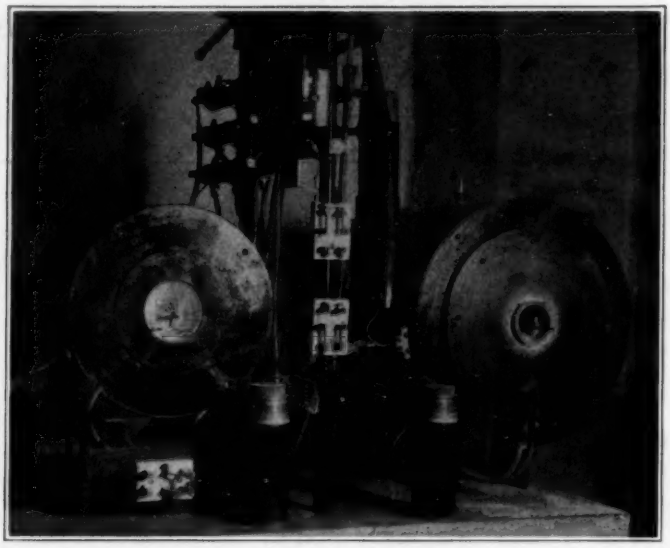

FIG. 1.

In the carbon spiral furnace set up by the writers, in exact replica of the one used by the Bureau, the rates of burning out of the spiral carbon coils were as follows:

	Number of Heatings	Mean temperature reached	Collective time period covering life of spiral
1st coil	6	Cone 7	30 hrs.
2nd coil	13	Cone 9 (12 max.)	75¼ hrs.
3rd coil	4	Cone 9 (10 max.)	25 hrs.

Installation of a new spiral involves practically reconstruction of the furnace. The spirals differ in electrical resistance requiring that each be "felt out" slowly and carefully, as to rate of current application to get a certain heat effect in a given time. The spirals differ greatly in homogeneity, and a corresponding tendency to form "hot spots." The longevity of each one is a function of these and many more varialbes.

It has not been possible to keep anything approaching clean oxidizing atmosphere in the test chamber, and no way has been found to prevent the oxidation of the carbon resistor. This slow combustion of the carbon spiral necessarily changes its cross-section, and hence its resistance, so that even after using a spiral for a time or two, and learning its general behavior, it is impossible to set any fixed schedule for current application as each heating necessarily differs from its predecessor.

IV. Consideration of a Platinum Resistor Furnace

Replacement of the graphite spiral furnace by a more practical tool, between the temperatures 1100 and 1500°C was desired. The entire list of possible metallic resistors was canvassed, and one after another rejected as not feasible: palladium on account of its low melting point (1550°C); iridium, ruthenium, and osmium (though of very high melting point) on account of their volatility, ranging from 30 to 500 times as great as platinum; molybdenum and tungsten because they cannot withstand oxygen at high temperatures. Only rhodium and platinum were left. The properties of rhodium are even better than platinum (melting point 1950°C, practically nonoxydizable, very low volatility, softness, good working properties, and abundant supply as an article of daily commercial use) remained the only real possibility.

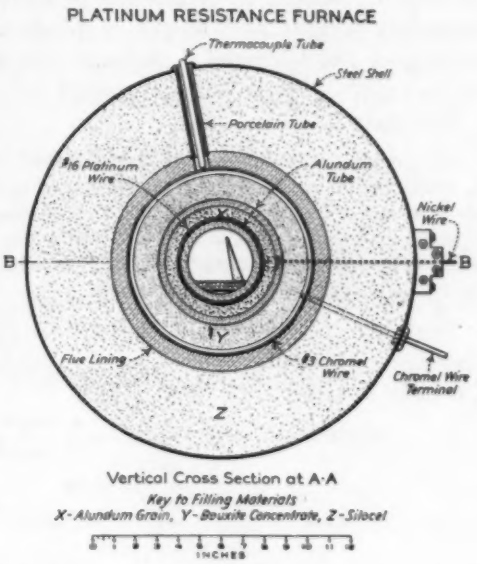

FIG. 2.

The manufacturers and refiners of platinum were unable to cite cases of the use of platinum resistances of a large size, or for a temperature zone as high as was necessarily contemplated by us. The conditions to be met in the design, in order to use the other equipment, transformers, rheostats, wiring, switches, and measuring instruments, were roughly as follows:

(1) Size of test chamber, not less than 3 inches on any axis; (2) shape of chamber, preferably a cylindrical tube, because of rigidity of form; (3) temperature to be attained, 1530°C; (4) time for one complete heating, 24 hours, if possible; and (5) atmosphere in test chamber, pure air.

While the fundamental calculations on conversion of electric energy into heat are not complex, the fact remains that there are numerous variables entering into the heat balance of any furnace, which are either unknown, or if known are difficult of calculation or measurement. Since the Chromel furnace gives an actual example of electrical input and heat production, it enabled these variables to be to some extent lumped off together, on the assumption that if the Chromel furnace would reach 1100°C, in a given time with a given electrical wattage, a similar furnace with platinum coil for resistance would follow a very similar curve, at least as far as 1100°C, and by extrapolation, the piece of the curve from 1100, to 1530°C, could be fairly well anticipated.

A. W. Smith of the Department of Physics, Ohio State University, was retained in an advisory capacity at this stage. The problem put up to him was: In a given furnace, whose performance is known, up to 1200°C, heated by a resistor of Chromel A wire, what would the necessary weight and length of platinum wire have to be not only to replace the Chromel A resistor, but also to carry the temperature up to 1500°C, in the same furnace?

The data involved are:

(1) Length of Chromel wire, 1678 cm. (55 feet); (2) temperature coefficient of Chromel A, 0.00011 ohm per degree C; (3) resistance of Chromel A coil at 20°C, 0.85 ohm; (4) resistance of Chromel A coil at 1200°C, 0.98 ohm; (5) resistance of pure platinum wire 1 cm. long x 1 sq. cm. area at 0°C, 0.0000105 ohm; (6) ratio of resistance of platinum at 20°C, to its resistance at 1400°C, 1:5.25; (7) resistance of platinum wire 1 cm. long x 1 sq. cm. in area at 1400°C, 0.0000551 ohm.

Professor Smith made the following analysis of this situation, Assuming platinum wire to have same length and same resistance as Chromel A wire:

$$\text{Resistance} = \text{specific resistance} \times \frac{(\text{length})}{(\text{area})}$$

$$0.98 = 0.0000551 \times \frac{1678\ \text{cm}}{\text{area}}$$

$$\text{Area} = \frac{0.0000551 \times 1678}{0.98} = 0.0943\ \text{sq. cm.}$$

Area 0.0943 sq. cm. = radius 0.0685 inch, or diameter 0.137 inch or between 7 and 8 gage, B & S

A platinum wire 55 feet long and of this diameter would cost entirely beyond reason for the purpose in view.

2. Increasing Voltage to 60 Using 60 volts on the platinum wire, *vs.* 45 volts on the Chromel A wire, with coils of the same diameter and length, what would the diameter of the platinum wire have to be, to produce the *same* heating

effect as the Chromel A? The resistance of the platinum coil is found by the following equation:

$$\frac{\text{voltage squared}}{\text{resistance of platinum coil}} = \frac{\text{voltage squared}}{\text{resistance of chromel coil}}$$

or

$$\frac{60^2}{R} = \frac{45^2}{0.98}$$

In which $$R = 0.98 \times \frac{60^2}{45^2} = 1.74 \text{ ohms}$$

Repeating calculation in paragraph I, with the new value just found, we have:

$$1.74 = 0.0000551 \times \frac{1678}{A}$$

$$\text{Area} = 0.0531$$

$$\text{Diameter} = 0.102 \text{ in. or about No. 10 B \& S}$$

This again is far too heavy a wire to be practicable in cost.

3. Increasing Voltage to 110 The next calculation was to determine whether increasing the voltage to 110 would sufficiently step up the heating effect, without too much investment in platinum.

Repeating this calculation of paragraphs 1 and 2, substituting 110-volt current instead of 60 volt, we get:

$$R = 5.86 \text{ ohm}$$

$$D = 0.0558 \text{ in. or between No. 15 and 16 gage B \& S}$$

This brings the cost of the platinum down to a figure more within the bounds of reason.

4. Heating Effect at 110 V The heating effect of the Chromel coil A already in use is:

$$\frac{\text{voltage squared}}{\text{resistance of coil}} = \frac{45^2}{0.98} = 2060 \text{ watts}$$

The heating effect of the platinum coil calculated in case 3 is the same, *viz:*

$$\frac{110^2}{5.86} = 2060 \text{ watts}$$

Checking further, the resistance of 55 feet of No. 15 platinum wire at 1400°C, we get:

$$\frac{0.0000551 \times 1678}{0.0165} = 5.6 \text{ ohms}$$

and the resistance of 55 feet of No. 16 platinum wire at 1400°C is

$$\frac{0.0000551 \times 1678}{0.0133} = 6.9 \text{ ohms}$$

The resistance, 5.86 ohms, falls between these two values, showing that a No. 15 wire is a little too large, and a No. 16 wire a little too small, for the heating effect desired.

5. Platinum-Rhodium Coil Messrs. Baker and Company stated that their commercial platinum was a more or less variable alloy, containing approximately 93–95% of platinum, and the 5–7% made up of various other metals of the platinum group, some of which are quite unsuited to the purpose in view, and recommended that we consider a coil of 80 platinum 20 rhodium, which they could furnish at substantially the same price as commercial platinum. The electrical constants of this alloy were given as:

Resistance per foot of No. 16 wire at 0°C = 0.052 ohms
Temperature coefficient per degree C = 0.0012 ohms

From this the resistance of 55 feet at 1500°C, was calculated to be 8.3 ohms, and its heating effect on 110-volt current at 1500°C is

$$\frac{110^2}{8.3} = 1460 \text{ watts}$$

This is materially less than that of the pure platinum coil, calculated in paragraph 4. But the advantage of the superior strength and hardness, the less tendency to crystallize, and the reduced volatility at high temperatures, of the 80% platinum 20% rhodium alloy, was a strong inducement to its use.

The Chromel A coil was found by actual measurement to be using approximately 25 amperes at 27 volts equalling 675 watts to reach 1100°C in 6 hours.

The controlling apparatus on the Chromel furnace would permit the application of 43 amperes at 44 volts = 1890 watts, or about three times what had been actually used. It seemed probable therefore that if the Chromel wire would stand the temperature, it would heat the furnace to 1500°C if 1890 watts were sup plied to it. But since the platinum-rhodium 16 gage coil was found good for only 1460 watts, an additional source of heat would have to be found.

6. Booster Coil By using the platinum-rhodium coil for its 1460 watts on 110-volt current, and encircling it at a safe distance outside with a Chromel A coil of the original capacity, for its 675 watts additional, or a total of 2135 watts, it seemed probable that the furnace would be capable of going up to 1500°C in a reasonable heating period.

V. Construction of the Platinum-wound Furnace, with Chromel A Booster Coil

Wire vs. Ribbon Type of Resistor

The use of foil or tape of platinum-rhodium was considered but finally abandoned, in spite of its almost universal application heretofore. The arguments for it are the much greater radiating surface, and the much more uniform covering of the tube to be heated, where the platinum is spread out in a thin even ribbon of foil. The objection to this for our purpose is its lack of ruggedness in resisting expansion and contraction,

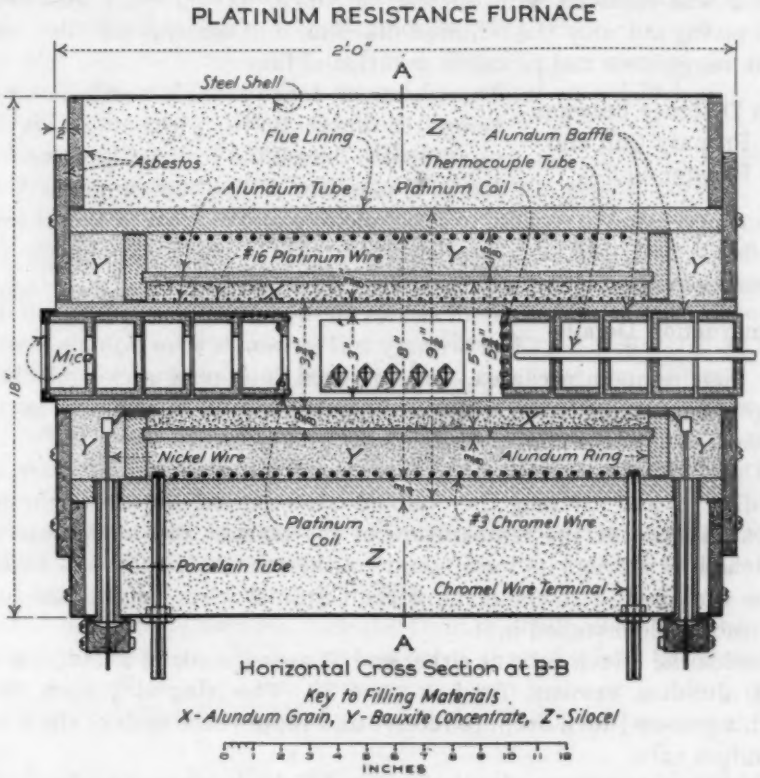

FIG. 3.

and greater likelihood of its burning through at some point. Dependability for daily use was one objective, and a round wire affords the least possible surface area per unit of cross-section. Its strength would be therefore greatest, and its radiating surface least.

The Winding

The platinum-rhodium wire was wound on the tube, centered on wooden mandrels in a lathe, and fed on under some tension, the ends of the coil being secured by clamps. The coil was then heated to anneal it, so that the coil would remain in

place. It was then smeared with alundum cement 518 mixed with paste, applied in several layers, and heated to burn out the paste and set the cement. The 55 feet, coiled on a tube of this external diameter ($3\frac{3}{4}$ inches), gives a center to center spacing of about $\frac{3}{8}$ inch.

The Booster Coil Since the booster coil would have to be exterior to the primary coil and some distance removed from it, it was apparent that a wire of much greater length would be required, or the coils would have to be spaced much further apart, if the same resistance was to be required. The original Chromel A coil of 55 feet No. 4 was replaced with 70 feet of No. 3, having equal resistance, and giving not only the required diameter and spacing, but also much more ruggedness and probable duration of life.

The Distance between the Primary Coil and the Booster Coil There being no data available, and calculations being too uncertain to yield much, it was necessary to determine by trial how far from the 80% platinum 20% rhodium primary coil it was necessary to remain, to avoid melting and rupture of the Chromel A alloy booster coil, and the distance was set at two inches for the first experiment.

Construction Details The drawings show details of the construction. The primary coil terminals were brought outside the high temperature area, and fastened into pure nickel blocks of large cross-section, from which pure nickel wire of heavy cross-section connected with the copper feed circuits.

The Chromel wire terminals were made by doubling the wire and welding it, and carrying the doubled cross-section outside to the feed wire. To enable the temperature of the booster coil to be carefully watched to prevent its burning out, a thermocouple tube was built in from the exterior to the level of the Chromel wires, and a basemetal thermocouple installed in it.

Inside the 8-inch tube at either end, is a ring made of alundum grain and alundum cement, fired at cone 20. This ring is $\frac{3}{4}$ inch thick, with a groove $\frac{1}{4}$ inch deep, to receive and support the ends of the 5-inch alundum tube.

By the arrangement of end plates and disks, it is easy to take out the two alundum tubes, or either of them, and the packing material, for examination or replacement, without touching the Chromel coil, or the external parts of the furnace. Once installed, this outer coil should last almost indefinitely, as No. 3 Chromel A wire will stand a lot of work, if kept below 1200°C.

Within the internal tube, are a series of five partitions at each end. These partitions are made with flanges, sliding in the tube freely, in effect making shallow flat bottomed cups. The outside dimensions of

these cups are $1\frac{5}{8}$ inches long, by $2\frac{1}{16}$ inches in diameter, with a $\frac{3}{16}$-inch wall. They are made of alundum grain and cement, fired to cone 20. The front set has a central opening for observation, and the back set has a $\frac{5}{16}$-inch hole for a pyrometer tube. Both sets have two $\frac{1}{8}$-inch holes, $1\frac{1}{4}$ inches apart, for the terminals of the heating coils to pass through. These heating coils necessarily have to be able to go a little higher than the temperature of the side walls of the tube, because of the slight draft of air passing longitudinally through the furnace at times, carrying out heat. Also, the observation hole in the front allows radiation. Hence, they have to be wired with platinum-rhodium resistors, calculated to give even heavier heating effect than the sides. The end coils each consist of 10 feet of No. 22 gage wire, of the 80% platinum 20% rhodium alloy, wound in a spiral on a $\frac{1}{8}$-inch rod, and imbedded in grooves cut in the front and back partitions. Each coil has a resistance of six ohms, together with a maximum of 12 ohms rheostat resistance, and is used in our case on a 60-volt current, but could be used on 110-volt equally well.

First Operation of the Furnace

For the first few runs, the furnace was tried on 60-volt current on the primary coil, with the regular current of less than 5 kilowatts on the Chromel booster coil. The latter functioned well, though a little slower than was anticipated. It was found by trial, that operating the Chromel coil alone, it could be given an amount of current which, using the automatic controller, would bring the furnace to 1000 or 1100°C starting at 4 P.M., and finishing at 8 A.M. The platinum coil would then be thrown into action and the temperature carried up.

As the heat from the primary coil began to work, the current had to be turned off progressively on the booster coil, to prevent overheating the Chromel. As the furnace neared its maximum, there was little current left on the booster, and the furnace still had not reached its desired temperature. It became apparent that it would be necessary either to increase the space between the two coils, or insulate more effectively in the space already provided. The latter expedient was tried.

A pure aluminum oxide, known as bauxite concentrate, grade A, was procured from the Aluminum Company of America, which is very fine-grained (300-mesh) and only one-half as dense as the fused alundum grain. It acts as a very good insulator, and its heat-resisting power without change of volume is also excellent. The alundum grain between the outer alundum tube and the Chromel coil was replaced with this lighter finer material. It proved to insulate the Chromel coil against the out-flowing heat of the primary coil, enough better than the alundum grain had done to save any other changes being made.

The maximum temperature which the furnace would reach on the 60-volt circuit as the result of several trials was 1460°C. Also, the time required was too long. It was apparent therefore that 110-volt current would have to be used, as indicated by the original calculations. This change being made, a temperature of 1533° was reached without using all the current for which the controls provided, and the time of the firing was shortened as much as desirable.

The fact that but little current was left on the booster coil during the last one hundred degrees rise of the furnace does not indicate that it is of no use. Its value lies in speeding up the operation, and still more in saving the platinum coil from many hours of service per heating. By encircling the primary coil with a hot zone, the heat gradient from that coil outward is greatly reduced. Even if the platinum coil, by hard-crowding and long-heating period, could heat the furnace to the desired temperature, the booster coil would still be worth while in shortening the period, and reducing the wear and tear on the costly metal.

The Performance of the Completed Furnace

The log of heating No. 126, made on December 8–9, 1926, is given in extenso, for the benefit of any who care to examine the details of the work.

The temperature equivalents of the millivolt readings on the cones are:

No. 16	1449°C	No. 19	Fouled on thermocouple wire
No. 17	1472°C	No. 20	1533°C
No. 18	1499°C		

These figures have been plotted on the accompanying graph from which several points are clearly seen.

(*a*) The unfortunate shut-off of city power for a few moments at 4 P.M., caused an ugly break in the curves and occasioned a delay of about forty minutes in the completion of the test, but had no other effect.

(*b*) The constant and even rise in the temperature in the cone chamber.

(*c*) The slight but steady increase in amperage on the primary platinum coil.

(*d*) The successful holding of the temperature of the Chromel booster coil at around 1260°C.

(*e*) The rapid decrease in amperage in the Chromel A booster coil beginning at 1200°C. This amperage was taken from a 220-volt power circuit, but had to be passed through a transformer, and cut down to less than 45 volts before passing to the Chromel coil. Since the voltage on this circuit changed with each change in the switches, it is reported in terms of 220-volts, though not used as such. The average voltage actually on the coil was probably about 27.

Speed of Operation The rate of temperature increase was:

1200–1300°C	75 min.	or 80° per hr.
1300–1400 "	140 "	or 43° " "
1400–1500 "	200 "	or 30° " "

The actual elapsed time on the last 100° was 240 minutes, but the shutting off of the power occasioned a clear loss of 40 minutes in the program of the operation. It would have been quite possible to drive the furnace up at a higher rate than was done, but for the purposes in view, this was quite fast enough. For other industrial purposes, the speed of operation might be a more critical factor in determining the value of this equipment. It is probable that at least 40° per hour between 1400 and 1500° can be safely reached and perhaps 50°; 60–75° per hour from 1300–1400°; certainly 100° per hour can easily be had from 1100° to 1300°.

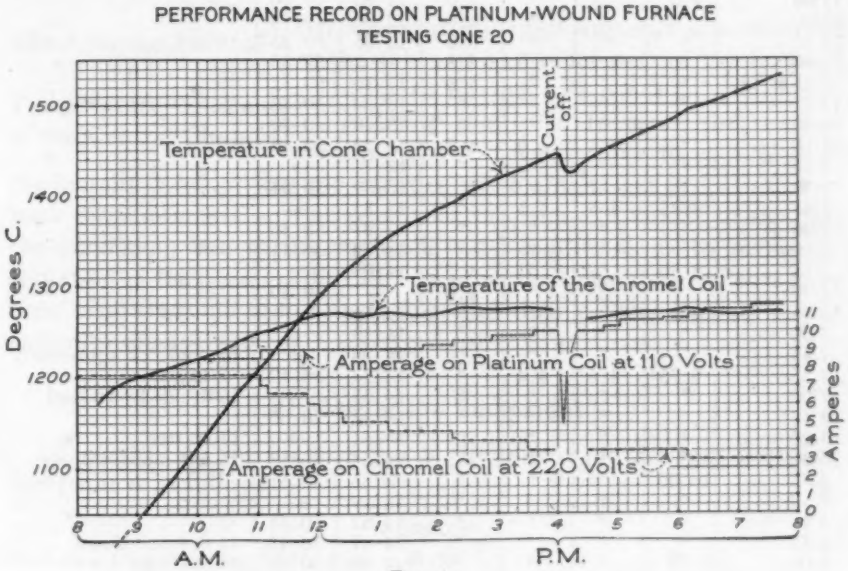

FIG. 4.

Current Consumption On the firing charted in Table I, the figures at the end of the period, when the furnace stood at 1533°C, were as follows:

	Amperes	Voltage	Watts
Platinum primary coil	11.5	110	1265
Platinum end coils	9.6	60	576
Chromel A booster coil	3.0	220*	660
			2501

* This was measured to the transformer at that voltage, but used at around 27 volts.

At 1200°, the amperage on the coils was as follows:

	Amperes	Volts	Watts
Platinum primary coil	9.00	110	990
Platinum end coils	7.00	60	420
Chromel A booster coil	7.00	220	1540
			2950

TABLE I

Time	Current Consumption				Thermocouple Readings in mv		Observations on Cones
	Amperes on Platinum Primary Coil	Amperes on Platinum Front Coil	Amperes on Platinum Rear Coil	Amperes on Chromel "A" Booster Coil	Platinum Rhodium in Cone Chamber	Chromel Alumel at Booster Coil	
5: P. M.	—	—	—	8.2	—	—	
8:00 A. M.	7.0	3.5	3.5	7.6	—	—	
8:20 A. M.	"	"	"	"	—	47.00	
8:40	"	"	"	"	9.62	47.70	
10:00	8.5	"	"	"	10.85	48.70	
10:32	"	"	"	"	11.42	49.15	
11:00	9.0	"	"	7.0	11.83	49.60	
11:10	"	"	"	6.6	12.00	49.70	
11:50	"	"	"	6.0	12.65	50.25	
12:00	"	4.2	4.0	5.5	—	50.35	
12:25 P. M.	"	"	"	5.0	13.10	50.37	
12:35	"	"	"	"	13.22	50.30	
12:50	"	"	"	"	13.40	50.30	
1:10	"	4.3	4.0	4.5	13.59	50.40	
1:30	"	"	"	"	13.74	—	
1:40	"	"	"	"	13.80	50.34	
1:45	9.25	4.5	4.3	"	13.83	—	
2:00	"	"	"	"	13.97	50.36	
2:10	"	"	"	"	14.02	50.41	
2:15	9.50	"	"	4.2	14.05	—	
2:20	"	"	"	4.0	—	50.50	
2:25	"	"	"	"	14.14	—	
2:30	"	"	"	"	14.18	—	
2:44	"	"	"	"	14.26	—	16 and 17 apparently started
2:55	9.75	4.6	4.4	"	14.33	50.49	
3:00	"	"	"	"	14.37	—	16 decidedly started
3:15	"	"	"	"	14.44	50.50	
3:20	"	"	"	"	14.51	—	17 started
3:30	"	"	"	3.5	14.53	50.53	16 one-quarter down
3:35	10.00	"	"	"	14.56	50.51	
3:40	"	"	"	"	14.59	—	
3:45	"	"	"	"	14.62	50.48	
3:55	"	"	"	"	14.67	50.45	16 one-half down
4:00	"	"	"	"	14.69	50.45	17 one-fifth down
—	5.00	?	?	?	—	—	Power on city circuit cut one-half off
4:10	8.00	?	?	?	14.45	"	
4:15	9.00	?	?	?	14.44	"	
4:20	10.00	?	?	?	14.51	"	
4:40	"	4.8	4.5	?	14.69	50.25	
4:47	"	"	"	?	14.74	"	16 touched base
5:02	10.25	"	"	?	14.84	"	
5:23	10.50	5.0	4.6	?	14.96	50.40	17 two-thirds over 18–19 started
5:33	—	"	"	?	15.02	—	17 touched base
5:45	10.75	"	"	?	15.10	50.40	18 ahead of 19 slightly
6:00	—	"	"	?	15.21	50.48	18 one-half down, 19 one-quarter
6:10	11.00	"	"	3.0	15.30	50.51	19 one-half over
6:26	11.25	"	"	"	15.35	—	18 touched base
6:40	"	"	"	"	15.44	50.37	20 started
7:05	"	"	"	"	15.56	50.38	
7:13	11.50	"	"	"	15.60	"	20 one-third over
7:27	"	"	"	"	15.68	"	20 one-half over
7:35	"	"	"	"	15.72	50.41	
7:44	"	"	"	"	15.76	50.42	20 touching base
7:45	"	"	"	"	—	—	
7:48	"	"	"	"	15.78	—	

The current will vary in different parts of the heating and with the rate of temperature increase, but it may be said to lie between 2.5 and 3.0 kilowatts per hour when at high temperatures and about 2 to 2.1 over the whole heating period.

A rough comparison between the carbon resistance furnace which was discarded, and the platinum resistance furnace is as follows:

Furnace	Heating No.	Cone	Hours in Operation	Kw. per hr. over whole heating	Kw. hrs.	Remarks
Carbon	97–98	12	6	5.0	30	Reduction unavoidable
Platinum	150	12	26	2.0	51	Good oxydizing atmosphere

Effect on the Furnace No apparent injury of any sort was observed to the tubes or any other part of the furnace.

Temperature Gradients in the Central Chamber Owing to having five cones in this space, and being compelled to move the thermocouple about to get it close to each cone at the instant it fell, it was too crowded to be able to get good front and back measurements on this particular heating. Suffice it to say that the conditions are so nearly black-body conditions as to make observation of the contents difficult. In other heatings, the gradients have been measured and found negligible, and their control entirely at the option of the operator.

VI. Cost of the Equipment

The cost of all the major units of equipment purchased in building this plant is as follows:

Furnace		
Steel shell, 23 x 18 inches, $4.86, support $1.00	$5.86	
Asbestos board, ½ inch, for ends	6.67	
Miscellaneous bushings, angles, screws, etc.	2.00	$14.53
Refractories		
3 in. alundum tube, 24 in. long	$13.23	
5 in. alundum tube, 18 in. long	15.18	
8 in. fireclay tube, 24 in. long	0.63	
Alundum rings and cups, home made	5.00	
Alundum grain	3.00	
Alundum cement No. 518	1.50	
Sil-O-Cel	3.00	
Bauxite concentrate	2.00	
Thermocouple sheath tubes	3.58	$47.12
Resistances		
Main 80% platinum 20% rhodium coil, No. 16 gage wire, 54 feet long	$1,773.75	
Two end coils, platinum rhodium, 22 gage, 10 feet each,	136.29	
Booster Chromel A coil, No. 3 gage wire, 70 feet	42.05	
Total on furnace		$1,952.09

CONTROLLING APPARATUS

For Platinum Coils		
3 KVA transformer, 220–110 volts	$36.33	
Rheostat, home made, Chromel wires, for main coil	30.62	
Bec Bro. Tubular Rheostat, 250 ohms, 2 amps., for main coil	14.00	
Ammeter, 15 amp. scale, for main coil	20.00	
4 Bec Bro. Tubular Rheostats, for end coils	32.92	
Switches, wire, loom, and minor supplies	20.00	$193.87
For Chromel Booster Coil		
5 KVA transformer 220–45 volts	$95.00	
Ratio switchboard	65.00	
Bec Bro. Tubular Rheostat, 4 ohms, 12 amps.	8.00	
Ammeter, 10 amp. scale	20,00	
Switches, wire, looms and minor supplies	7.00	$195.00
Temperature Measuring Equipment		
Type K, Leeds and Northrup potentiometer outfit	$425.00	
Heavy, standardized platinum-thermocouple for reference purposes, 30″ long 0.6 mm. gage,	75.00	
Two ordinary platinum thermocouples, for daily records, 0.4 mm. gage at $25.00	25.00	
Spool Chromel P. wire, 1 lb., for base metal couples } Spool Alumel wire, 1 lb., for base metal couples }	12.60	
Gold wire, for calibrations and reference	10.00	
2 Thermos jars, for cold junctions	5.50	$578.10
Grand total		$2,980.71

VII. Conclusions

The practical value of the work reported in the foregoing remains to be disclosed by experience. Nothing new is claimed for the principles, as platinum resistance furnaces have been in use for years. But previous platinum wound furnaces all seemed entirely too fragile and of too short life, and too small size, to make them serviceable for such purposes as ours. And apparently, electric furnace construction has not yet been carried to a point where definite calculations can be made with confidence. It was necessary to start with the nearest thing available, calculate as far as feasible what had to be done, and then carry construction into the unknown field and test it out. The result is gratifying, at least temporarily. With very little readjustment, the furnace did develop the required temperature, without apparent overstrain to any of its parts, and with as much speed as is needed or desired.

Of course the life of the platinum coil is the crux of the whole matter. The cost of the platinum is so great, that unless it can be shown that it is good for a long period of use, it would not be worthwhile for any but very exceptional plants to install such a furnace. If it can be shown that such a furnace, used with the skill and care that it deserves, is good for a long period of use, and that the replacement cost of the platinum after crediting up its salvage value (85% to 90% of its new

cost), makes the operation cost per heating reasonable, then the work will have value for other uses than exceptional laboratories.

The only data thus far obtainable as to the life of the furnace is derived from a study of the current consumption to carry the furnace up to a given temperature when first installed, and after a period of use. There have been made thus far 31 heatings, all as high as cone 6 and most of them to cone 10, and there is no difference observable between the electric input and rate of temperature increase as yet. This indicates that no changes of importance have yet taken place in the resistor coil.

It is our intention to keep this furnace busily employed for the next year or so, and we hope to report to this SOCIETY in another year the facts as to its longevity and cost of operation, maintenance and repairs included, as the facts develop.

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In Germany.....June 7 to June 14
In Czechoslovakia.....June 14 to June 20
At Milan, Italy.....June 23
In France.....June 24 to June 30

Extension of these trips will be arranged for those who will wish to go to other places and to spend a longer time abroad.

CERAMIC ABSTRACTS

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Abrasives

PATENTS

Aggregate-cement tile. G. N. JEPPSON. U. S. 1,619,733, March 1, 1927. A tile comprising a precast cement body having embedded in its top surface aggregates of ceramic bonded abrasive grains interspersed with colored chips of vitrified ceramic material which are so arranged with the surrounding areas of cement that the aggregates will contact with and prevent foot gear from slipping thereon, the tile being dense and substantially nonabsorbent of water and having a ground and polished surface made up largely of the aggregates and the ceramic chips which are adapted to receive substantially all of the wear and protect the surrounding cement.

Terrazzo tile and method of making the same. G. N. JEPPSON AND C. L. LEAFE. U. S. 1,619,734, March 1, 1927. The method of making a terrazzo tile comprising the steps of wetting porous chips of bonded abrasive grains with water, mixing them with dry cement, and thereafter developing a desired moldability therein, shaping a tile therefrom and grinding off a layer from the tile to provide plane faces on the exposed chips.

Safety-tread unit. E. VAN DER PYL. U. S. 1,619,773, March 1, 1927. A safety tread unit comprising antislipping tiles of bonded abrasive grains partially imbedded in a plastic and deformable backing material which is not meltable under ordinary climatic conditions and is capable of adhering to and supporting the tiles and yet adapted to conform to slight irregularities in a substantially plane supporting surface and make a firm contact therewith so that the tiles may be supported on a good foundation through which shocks and vibrations are not easily transmitted and an open meshed reinforcement embedded in said backing and adapted to position and maintain the tread faces substantially in one plane.

Art

Vases and bronzes, recent accessions in the Classical Department. GISELA M. A. RICHTER. *Bull. Met. Mus. Art*, **22** [1], 17–21 (1927).—Among a number of miscellaneous vases and bronzes being shown in the Room of Recent Accessions are a few pieces of great importance. Among the new vases, 9 are early examples. One is an Etruscan bowl on a standard, of red bucchero ware with geometric decoration in white. An Etruscan oinochoë of the 7th century B.C. has frieze of animals and monsters incised on black background, with purple and yellow as accessory colors. This piece has a large crack due to overcrowding in the kiln, and probably was used in a tomb, instead of for needs of daily life. There are also, a Mycenaean stirrup vase with decoration of lattice work with dotted circles and zigzag lines, and several Corinthian pyxides, which are fine, decorative pieces. There is a small Rhodian or Fikellura amphora with delicate decoration, and 3 other small and dainty pieces, a Proto-Corinthian lekythos, a pyxis with conventionalized birds, and a beautifully preserved geometric lekythos with a row of human figures holding hands. There are several 6th century Athenian vases with their standardized black-figured technique. These show the fine sense of composition of the 6th century Athenian potter both in shapes and spacing of decoration and have the excellent black glaze which is one of the reasons for the remarkable success of Athenian pottery. One of the finest of the new red-figured vases is an amphora with representation of Eos pursuing Kephalos, by the Meletos painter. There is a lekythos decorated with a delicately drawn figure of Athena, holding a spear and the ornament from the prow of a ship. The charming delicacy of the later style of Athenian red-figured painting is well illustrated in several new vases of small size. A Hellenistic plastic vase with a Seilnos sitting by an amphora is a beautifully modeled piece, well preserved. Among the newly acquired bronzes there are a beautifully proportioned hydria, a statuette of a young disk thrower, a Greek mirror with head of a satyr in relief on cover, and a portrait head broken from a large statuette which is a fine piece of modeling of Roman date. A.A.A.

An important loan of early Chinese pottery. S. C. BOSCH-REITZ. *Bull. Met. Mus. Art*, **22** [2], 44–46 (1927).—The exhibition of early Chinese potteries has been rearranged so that only the finest pieces are being shown. Through the generous loan by Mrs. Samuel T. Peters, from the collection made by her late husband, the assortment of Sung pottery shows all the different varieties in the best and selected specimens. The cases of Tz'u chou, Chun yao, Chün, Ting yao, show the best specimens of their kinds, and there are fine examples of five dynasty porcelains of about the year 1000. The T'ang and the Han potteries are also well represented and there is even an example of the prehistoric Chinese pottery recently discovered by John Gunner Andersson, which has just been presented to the Museum. A.A.A.

Two theatre vases. GISELA M. A. RICHTER. *Bull. Met. Mus. Art*, **22** [2], 54–58 (1927).—On a class of South Italian vases of the 4th century B. C. there appear scenes from the Phlyakes, the farces which were developed in southern Italy in connection with the Doric comedy in Silicy. The vase paintings are important in showing us what they were like, the farces themselves not having survived. The Museum has just acquired a South Italian vase of the bell-krater type which is decorated with the representation of a parody of a court scene. These farces were generally parodies of tragedies, and in a boisterous vein. A second bell-krater has a representation from the theatre. Three bearded satyrs covered with white fur are playing the lyre, confronted by a young flute-player. The satyrs are members of the chorus in a satyric drama, at the festival of the Panathenaia. The Greek drama was developed from the satyric play, yet the satyric play survived as such, and in 5th century B.C. was performed as the concluding part of a tetralogy, to afford a comic relief after 3 tragedies. This vase can be dated in

end of 5th or beginning of 4th century B.C., the same period as the famous theatre vase in Naples, with representation of chorus of satyrs, and is an Athenian product. Both the play and the artist who represented it are on a higher level than those of the South Italian krater. A.A.A.

Greek vase painting in red-figured style. J. S. GREEN, JR. *International Studio*, Feb. 1927, pps. 21–28.—The simplicity and directness of Hellenic civilization stands out in its art; in gems, coins and sculpture, as well as in vase-painting. The vases present almost the only surviving examples of Greek painting during the 6th and 5th centuries, and the subjects painted on them afford an unrivaled opportunity to discover what Greek life and religion were like. Many were found in Etruscan tombs, which accounts for the fact that so many have been preserved. These vases have been eagerly sought for and collected since the time of Sir William Hamilton, who was British ambassador to Naples at the beginning of the 19th century. Close inspection and study of characteristics has led to an accuracy in determining the artist responsible for most of the vases known today. Greek vase painting is divided into "black-figured style" and "red-figured style," the latter representing the highest point. The rest of the article is given to the consideration of the work of 5 important artists: the Berlin amphora painter, the Panaitios painter, the Brygos painter, Douris, and Makron. There are numerous illustrations of pieces attributed to these painters which are now the property of various museums. The archaic stiffness of the drawing of the Berlin amphora painter is disappearing and making way for more realistic treatment in the work of the Panaitios painter. In the Brygos painter's work, these 2 tendencies balance. Douris was a prolific painter, romantic and always suave and correct, although the actual drawing was sometimes careless and unoriginal. Makron was credited with the decoration of more red-figured vases than any other painter. He was unsurpassed in the drawing of soft flowing draperies and had a fondness for introducing women into his pictures. J. D. Beazley of Oxford, is at present the greatest authority on Greek red-figured vases and his work has been largely responsible for the present increased interest in Greek vase-painting. A.A.A.

The constants of color: hue, purity, and luminosity. C. W. GAMBLE. *Chem. and Ind.*, **46**, 126–27 (1927).—Hue is the color itself, luminosity its brightness, purity its freedom from admixture. If white is added to any color to the extent of 75 times its luminosity, the color sensation disappears, though this ratio is not the same for all colors. More white can be mixed with orange, without its effect being perceived, than with green, and still more than with blue. It is far easier to observe fine detail by monochromatic light than by heterochromatic light. The effect of a variation of illumination is shown by the fact that, of 2 fabrics, one showed moss-green in daylight and brown in tungsten light, the other showed indigo-blue in daylight while in tungsten light it was dull red. Lord Rayleigh demonstrated that when light passes through a turbid medium it is scattered inversely proportionally to the fourth power of the wave-length. An increase in the number of particles gives a longer wave-length. H.H.S.

Art and industry of glass. HENRY CREANGER. *Amer. Glass Rev.*, **46** [21], 21–22 (1927); reprinted from *Bull. Amer. Ceram. Soc.*, **6** [1], 29–30 (1927); see also *Ceram. Abs.*, **6** [3], 91 (1927). E.J.V.

Mathias Grunewald and glass staining. J. Z. *Diamant*, **47** [36], 770–72 (1925).—A historical discussion of glass staining, masters of the art, and their work. E.J.V.

Researches on Chinese-red glazes. GERHARD KLITZKE. *Keramos*, **5** [3], 133–34 (1926).—A discussion of blood-red glazes obtained by a blending of 75% of a soft porcelain glaze with 25% of a proportionally alkali-rich frit of extraordinarily low fusibility, with a copper content of between 0.09 and 0.15%, and a zinc content of 2% on an average, fired in a reducing atmosphere. E.J.V.

Art in the pottery and glass trade. ANON. *Pottery Gaz.*, **52** [597], 473–74 (1927).—An extract of a report on industrial art by a "Committee on Industry and Trade," taking up under "Pottery" the types of pottery and design, influence of methods of production on design, designers, training of designers, modelers, and registration of designs, and under "Glass" sources from which designs are obtained, training of designers, status and remuneration of designers, functions of the workshop designer, and protection of designs. E.J.V.

Effect of the electromotive series of the metals in ceramics. T. DA MILETO. *Corr. de Ceramisti*, **7**, 31 (1926).—Zinc filings sprayed over a body before firing leave no discolorations if the body contains no coloring oxides, but if a little cobalt or iron is present, blue or brown stains appear. The concentration of the cobalt and the iron round the zinc is attributed to the potential difference of the metals. The effects produced by well-known glazes containing zinc oxide as well as the coloring oxide, and by aventurine glazes, which contain several metal oxides, are attributed to the same cause. (*Trans. Ceram. Soc.* [Eng.])

Glass etching by hydrofluoric acid. J. SCOTT. *Glass*, **3**, 409 (1926).—The process is briefly described. Photomicrographs are reproduced showing the effect of both the fumes and the liquid acid on glass. (*Trans. Ceram. Soc.* [Eng.])

Practical notes on art pottery. E. KILLIAS. *Keramos*, **5**, 371 (1926).—Ordinary clays containing lime and iron, which are plentiful in many districts and are for the most part used in making bricks, may, if properly prepared, be used for making all kinds of pottery. In some cases the ware is decorated with a colored slip (engobe), in others, white or colored glazes are used. The technique of these 2 types, engobe and faience, is discussed in general outline. (*Trans. Ceram. Soc.* [Eng.])

Color and composition of antique glasses. B. NEUMANN. *Zeit. angew. Chem.*, **38**, 776 (1925).—The analyses of 38 glasses from the period 1400 B.C. to 600 A.D. are given. The alkali content is found to be too great in relation to the silica content. The smooth surface retained by some of the glasses is held to be due to the lime and magnesia content. (*Trans. Ceram. Soc.* [Eng.])

Cement, Lime, and Plaster

Rate of drying of wall plasters. ANON. Bur. Stand., *Tech. News Bull.*, No. 118, pp. 2–3 (1927).—Tests on rate of drying of wall plasters made on panels or plaster 4 x 6 inches held in wooden frames suspended within a cabinet by means of wire attached to balance arm. Temperature and humidity are controlled. Determinations have been made at 22, 30, and 37°C using air of about 65 and 95% relative humidity. Results are given on 3 plasters of varying thickness. R.A.H.

The effect of certain materials in the finish coat of plaster. ANON. *Proc. A.S.T.M.*, **26** [1], 241–43 (1926).—A report on the condition of the 98 panels of plaster erected at the Bureau of Standards in Feb. 1922. A summary is given in which is included the effect of various chemical compounds on the finish coat. R.A.H.

Report of special subcommittee on survey of tension tests of Portland cement for 1925. *Proc. A.S.T.M.*, **26** [1], 205–17 (1926).—This survey probably constitutes the most comprehensive statistical study of cement tests which has ever been carried out since it summarizes the results of over 1,000,000 briquet tests. Data collected from 177 laboratories representing 41 states and 3 Canadian provinces. R.A.H.

Notes on the chemical and microscopic determinations of gypsum and anhydrite. H. F. GARDNER. *Proc. A.S.T.M.*, **26** [1], 296–301 (1926).—A discussion tending to show the possible inaccuracies in the present methods of chemical and petrographic analyses of gypsum and anhydrite. R.A.H.

Plant of Southern Gypsum Co. ANON. *Rock Products*, **30** [3], 41–45(1927). F.P.H.

Plasticity of finishing limes. H. T. BRISCOE AND F. C. MATHERS. *Rock Products*, **30** [3], 50–54(1927).—A study of the effects of various conditions of calcination and hydration on plastic properties of hydrated limes. It has been found that a medium temperature, 1050 to 1150°C under laboratory conditions, rather than an extremely low or an extremely high temperature is best suited for the production of plastic finishing lime. The effect of the presence of magnesia is studied. F.P.H.

Some of the changes taking place in a rotary cement kiln. E. S. AND W. A. ERNST. *Rock Products*, 30 [3], 62–64 (1927).—A study of the physical and chemical reactions which occur in the different zones of the cement kiln. Chemical analysis of cement clinker at different positions in the rotary kiln are given. F.P.H.

Effect of chloride and metallic sulphates on hardening of sand-lime mortars. F. JUSTIN-MÜLLER. *Rock Products*, **30** [3], 79(1927). F.P.H.

Standardizing aggregate names. ANON. *Rock Products*, **30** [4], 39(1927).—An attempt to put an end to the confusion that comes from customers having different names for the same materials. F.P.H.

Synthetic gypsum, its recovery and uses. ROBERT S. EDWARDS. *Rock Products*, **30** [4], 42–44(1927).—Discussion of problems in utilization and description of operations of commercially successful block plant. F.P.H.

Progress in scientific control of lime manufacture. ANON. *Rock Products*, **30** [4], 50–51(1927).—A résumé of some of the more important investigations carried out recently. A bibliography on recent articles is given. F.P.H.

Recent improvements at Edison Portland Cement Co's. plant. ANON. *Rock Products*, **30** [4], 53–59(1927). F.P.H.

A study of Portland cement strength characteristics. ANON. *Rock Products*, **30** [4], 76(1927).—An abstract of *Bull.*, No. 17 of the Engineering Experiment Station of the Kansas State Agricultural College. F.P.H.

A modern gypsum products plant in Montana. R. M. CALKINS. *Rock Products*, **30** [5], 34–37(1927).—A description of the plant of the Northwest Gypsum Products Company which makes stucco and tile. F.P.H.

American Concrete Institute papers discuss aggregates and cement. ANON. *Rock Products*, **30** [5], 49–53(1927).—Abstracts of papers presented before the American Concrete Institute, Feb. 22, 1927. Following papers are abstracted: (1) "Qualifications of Different Kinds of Natural Stone as Concrete Aggregate," by G. F. Loughlin, (2) "Coarse Aggregate as a Field for Needed Research," by H. J. Gilkey, (3) "Portland Cement in Concrete Engineering," by R. H. Bogue, (4) "Time as a Factor in the Study and Use of Cement," by P. H. Bates, (5) "Water-cement Ratio as a Basis of Concrete Quality," by Duff A. Abrams. F.P.H.

Research on the hydration of dicalcium and tricalcium silicate. BECKMANN. *Zement*, 37–40, 55–58(1927); *Rock Products*, **30** [5], 74(1927).—The compounds were made by heating a properly proportioned mixture of pure $CaCO_3$ and SiO_2 to 1000°C in a muffle, mixing it with distilled water to a plastic paste, from which rods, 5 mm in diameter and 15 cm long, were formed. These were dried at 110°C in a carbon dioxide blast until they acquired sufficient strength. Their chemical composition was then determined on a sample rod and the rods melted in an oxyacetylene flame. The drops were quenched in mercury. The study of the hydration processes consisted of observing the rise in temperature and the change of electrical conductivity during hydration. A thermometer graduated to 1/50°C was inserted into the setting mass. Only slight thermal effects were noted in the hydraulic and nonhydraulic forms of $2CaOSiO_2$.

The hydration of $3CaOSiO_2$, however, takes place with a considerably greater rise in temperature. The electric conductivity was measured by Kohlrausch's method. In all cases a marked increase of conductivity was noted at the start until a maximum value was reached. With low conductivity during hydration the maximum value was reached soon. The conductivity of $3CaOSiO_2$ did not show as pronounced changes as that of $2CaOSiO_2$. All samples which, regardless of the method of handling, reach the same consistency in the same period of time (assuming equal quantities of water and thorough mixing) showed the same thermal and electrolytic phenomena with relation to time. The setting process is to be regarded as a colloidal reaction. This coagulation can be produced by a sufficient quantity of electrolytes or by a sufficiently high concentration of the solution. The high lime content of the compound $3CaO \cdot SiO_2$ furnishes favorable conditions for the gel formation at the start, so that the coagulation process predominates absorbing more ions than are produced by the decomposition of $3CaO \cdot SiO_2$. B. is of the opinion that the compound $3CaO \cdot SiO_2$ is a solid solution of one molecule of CaO in $2CaOSiO_2$. The setting process of $3CaOSiO_2$ can then be divided into two reactions: the coagulation of $2CaOSiO_2$ and a parallel strong exothermic hydration of the lime dissolved in $2CaOSiO_2$. Additional tests were made to determine the quantity of dissolved lime and the quantity of water absorbed by the silicates. F.P.H.

Specific heat of Portland cement clinker. FRITZ HARTNER, JR. *Zement*, **57** (1927); *Rock Products*, **30** [5], 74(1927).—H. determined the specific heat of Portland cement clinker of the following composition: Loss on ignition, 0.14%; silica, 23.26%; alumina, 6.06%; iron oxide, 2.58%; lime, 65.80%; magnesia, 1.40%, and sulphur trioxide, 0.43%. From 0.2 to 0.3 grams of clinker were heated in an electric furnace and the specific heat determined at different temperatures by the calorimeter method, checking against a known copper sample. The data as tabulated are:

Temperature Interval			
Degrees C	Specific heat	Degrees C	Specific Heat
18–130	0.205	18–720	0.272
18–230	0.223	18–835	0.278
18–390	0.247	18–930	0.281
18–500	0.258	18–1035	0.31
18–610	0.266	18–1048	0.32

Above 950°C specific heat determinations could not be checked. Portland cement clinker is considered by H. as a nonhomogeneous system, the components of which begin to melt at 950–1000°C and this melting heat added to the specific heat at that temperature, possibly accounts for the abnormal rise of specific heat observed. F.P.H.

Testing raw materials for cement making properties. ANON. *Zement*, 917–18 (1926); *Rock Products*, **30** [4], 80(1927). F.P.H.

Constitution of Portland cement. ANON. *Zement*, 610–12, 643–46(1926); *Rock Products*, **30** [5], 74(1927).—Review of the investigations carried out by Shepherd, Rankin, Wright, and Janecke. F.P.H.

A modern lime kiln. H. HÄLBIG. *Stahl u. Eisen*, **46**, 1119(1926); *Tonind. Ztg.*, **50**, 740(1926).—A description of a new kiln, with accessories is given, together with details concerning operation, fuel consumption, etc. (*Trans. Ceram. Soc.* [Eng.])

The compound $8CaO.2SiO_2.Al_2O_3$ as the "Alite" of Portland cement clinker. ERNEST JÄNECKA. *Zement*, **14**, 272–74(1925).—The physical and optical properties of the compound $8CaO.2SiO_2.Al_2O_3$ described by J. and by Dyckerhoff seem to correspond with the properties of "Alite." (*C. A.*)

PATENTS

Manufacture of Portland cement. CARL PONTOPPIDAN. U. S. 1,618,295, Feb. 22, 1927. The improvement in the method of making Portland cement with an admixture of gypsum which consists in preventing the subjection of the gypsum during admixture to a temperature such as to effect conversion of the gypsum to plaster of Paris.

Oxychloride cement and method of making same. H. M. OLSON. U. S. 1,619,534, March 1, 1927. A cement comprising magnesium oxide, 1% of a mixture consisting of 75 parts of mineral oil and 25 parts of beef fat, and magnesium chloride within the percentages of 15 to 25 parts.

Rotary furnaces for firing cement and the like. A. SCHMID. Eng. Pat., 253,819, Jan. 4, 1926. The discharge head of a rotary furnace is constructed at its lower end as a cooling chamber, to which air is admitted under pressure. The air passes from the cooling chamber through the material and is then utilized for combustion purposes. In an alternative construction, the head widens out at the lower end to form a hopper-shaped cooler, within which is a cone, having a louvre-like upper part. The fired material falls in a thin layer over the cone. Air under pressure is introduced into the cone and passes through the louvre opening over the material. (*Trans. Ceram. Soc.* [Eng.])

Gypsum processing. ANON. Ger. Pat. 438, 172; *Rock Products*, **30** [5], 74(1927). A gypsum product said to be more resistant to weather is made by calcining gypsum with silicic acid or clay in the presence of steam at temperatures of 1100°C or over.

F.P.H.

Enamels

Sheet steel cooking ware white enamels economically suitable for use in China. CHI-FANG LAI. *Jour. Amer. Ceram. Soc.*, **10** [3], 150–62(1927).—The research was carried on to develop data on sheet steel enamels which would be good enough and cheap enough to use in China. Substitutes for tin oxide were tested. An efficient and cheaply constructed kerosene fired enameling furnace was designed and built. Little could be gained by work on the ground coats. Sodium antimonate and calcined alumina yielded the cheapest enamels with quality almost equal to enamels made with tin oxide. Zirconium oxide yielded the best results when tested with acids. Cryolite could be reduced to the minimum and with benefit to the resulting product. High feldspar enamels proved to be most satisfactory. High zinc oxide content greatly increased the gloss but lowered the opacity. Calcined alumina failed when used alone.

Effects of composition on the properties of ground coat enamels for sheet steel. W. N. HARRISON AND H. G. WOLFRAM. *Jour. Amer. Ceram. Soc.*, **10** [3], 163–79(1927). —A series of ground coats was developed about each of three refractory bases, one of which consisted of flint and feldspar in a ratio frequently used commercially, another consisting of feldspar only, and the third of flint only. In each case the refractory portion was 58.5 parts of the whole. Besides the refractory, a "fixed addition" of 11.5 parts, comprised of 0.5 cobalt oxide, 1.0 manganese oxide, 5.0 boric oxide, and 5.0 sodium oxide, was used in every enamel, bringing the basic constant portion for each series to 70 parts of the whole. The variable portion in each series was made up of equal parts of three constituents commonly used in enameling, chosen from a total of six in such a way that every possible combination was employed, making a total of twenty enamels in each series. All were given two cover coats of a standard white and tested for resistance to mechanical and thermal shock. In general the ingredients which were most conducive to resistance to the test treatments were flint in the refractory portion, and sodium oxide in the variable portion, constituted of fluxes. Also, boric oxide favorably influenced resistance to mechanical shock in the series containing both flint and feldspar.

Resistance to mechanical and thermal shock in ground coats was considerably less affected by variations in expansivity than is the case in cover coats, the influence of that factor appearing to be partially obscured by other factors. E.J.V.

Enameling plant at Chattanooga, Tenn. EMERSON P. POSTE. *Ceramic Age*, **9** [2], 44–47 (1927).—A description of the Chattanooga Stamping and Enameling Co., of the different stages of manufacture, and of the methods used in technical control. A diagram and photographs are given. A.E.R.W.

Detroit's modern porcelain enameling plants. ANON. *Fuels and Fur.*, **5** [2], 155–60 (1927).—A brief description of 4 distinct types of wet process plants, each characteristic of the type of work produced and the fuel used, illustrated with photographs. A.E.R.W.

PATENTS

Device for coating articles with glass, enamel, quartz, or metals. M. U. SCHOOP. U. S. 1,617,166, Feb. 8. The coating material is applied by use of a blow-pipe projection device. (*C. A.*)

Enameling of cast and sheet metal. C. TOTOT-GIBARU. Eng. Pat. 262,159, June 16, 1925. A process for enameling metal by the "dry" method consists in applying a mixture of silica 2–25%, zinc oxide 20–35%, hydrated borax 35–70%, alkali nitrate 2–20%, alkali fluorides 0–8%, and calcium carbonate 0–30%. If additional opacity is required, antimony oxide, or stannic oxide is added. A decorative effect may be obtained by superposing on the above enamel, by the dry method, a mixture containing 5–15% SiO_2, 1–3% Al_2O_3, 10–20% CaO, 30–40% ZnO, 12–18% alkalis, 15–30% B_2O_3, 1–3%F, with oxide of iron, cobalt, or manganese to color. (*Brit. C. A.*)

Glass

New type of tunnel tank replaces day tank. WARREN S. WILLIAMS. *Jour. Amer. Ceram. Soc.*, **10** [3], 205–209 (1927).—Current retail distribution methods compel the glass manufacturer to be prepared for rapid changes in style, designs, and colors. Small flexible, producing units capable of accurate control and permitting rapid color changes or composition of glass aid in maintaining a close ratio between production and current sales. Day tanks are elastic in operation, but are not as economical or reliable as continuous tanks. A day tank was replaced with a tunnel tank (2 feet wide by 20 feet long) of equivalent melting capacity per shift. Details of construction, drawing, gas consumption, filling, and operation are given. Advantages gained: dependable production with uniform color, melting conditions stabilized and assured, producing capacity increased threefold without increasing fuel or labor costs, repair production loss cut, repair labor and material costs reduced.

Belgian glass industry prospers. ANON. *Ceramic Age*, **9** [2], 39 (1927).—Production of plate glass for the last 3 months of 1926 increased from 87 to 90% of the theoretical maximum capacity. A brief analysis of the situation is given. A.E.R.W.

Flat glass trade in Chile. ANON. *Ceramic Age*, **9** [2], 47 (1927).—A review of the conditions obtaining in the flat-glass trade in Chile. A.E.R.W.

Glass technologists gather in Detroit. ANON. *Amer. Glass Rev.*, **46** [21], 15–16 (1927); *Nat. Glass Budget*, **42** [44], 3 (1927).—A brief record of the papers read in the Glass Division meetings of the AMERICAN CERAMIC SOCIETY. Short abstracts of a few of the papers are given. E.J.V.

Glass manufacturing developments in Russia. J. F. PONOMAREFF. *Amer. Glass Rev.*, **46** [21], 17–18 (1927).—Of over 200 glass works in Russia which were in operation before the Revolution, about 100 are now operating. Machine production is in its infancy but is becoming necessary due to the dearth of skilled workmen. Research

institutions for glass and ceramics have been formed at Moscow, Tomsk, Leningrad, and Kharkov. Raw materials for glass, including sands, natural sodium sulphate, and limestone of great purity, are abundant in Russia. E.J.V.

Conditions in German glass industry reviewed in an interesting address. W. E. S. TURNER. *Amer. Glass Rev.*, **46** [23], 15(1927); reprinted from *Pottery Gaz.*, **52** [596], 277–82(1927); see also *Ceram. Abs.*, **6** [4], 136(1927). E.J.V.

Development of plate glass pot filling processes. J. W. CRUIKSHANK. *Glass Indus.*, **8** [3], 58–60(1927).—The old method of filling plate glass pots by hand in 3 fills is described in detail. Modifications in the process are also mentioned. The difficulties in filling glass pots which are avoided in continuous tank operation are discussed. Methods of filling pots while in the furnace which have been tried and abandoned are listed. A new filling machine devised by the Cruikshank Engineering Co., which can be used to fill pots in the arch, is described as to makeup, operation, and equipment. E.J.V.

Aluminum hydroxide for the manufacture of opaque glass. ROBERT SCHNEIDER. *Glass Ind.*, **8** [3], 62–63(1927); *Die Glashütte*, **56** [36], 703–704(1926).—Opaque glass cannot be produced unless enough alumina (Al_2O_3) is introduced to bring the amount up to 3% in the finished glass. Aluminum hydroxide, free from iron, is especially adapted for this purpose. The method of preparing it from bauxite ($Al_2O_3.2H_2O$) is described. Fluorine must also be used to obtain opaque glass. A French patent for producing a purely white, opaque glass gives the following batch and composition.

Batch		Composition	Per Cent
Sand	100	Silica (SiO_2)	66.81
Red lead	16	Alumina (Al_2O_3)	7.73
Fluorspar	6	Boric acid (B_2O_3)	0.48
Aluminum hydroxide	18	Sodium oxide (Na_2O)	10.38
Soda ash	25	Potassium oxide (K_2O)	0.62
Saltpeter	2	Calcium oxide (CaO)	2.83
Borax (crystallized)	2	Lead oxide (PbO)	10.42
Salt	5.5	Fluorine (F_2)	1.27
	176.5		100.54
		Deduct O_2 for F_2	0.53
			100.01

The principal advantages of using aluminum hydroxide are: (1) possibility to obtain a dense opacity in the common fluorine containing batches, (2) the small iron content of the glass prevents too much light absorption and "low color" glass, (3) opaque glass low in fluorine can be made, by use of salt, which increases the life of the pot. E.J.V.

Scientific paper dealing with nonglare mirrors. F. L. O. WADSWORTH. *Nat. Glass Budget*, **42** [43], 3(1927).—A treatise on the scientific principles which control the construction of nonglare mirrors. An explanation from the standpoint of physiological or psycho-physiological optics. E.J.V.

The analysis of soda-lime glass. G. E. F. LUNDELL. *Nat. Glass Budget*, **42** [44], 10(1927).—An abstract of a paper presented at the AMERICAN CERAMIC SOCIETY meeting in Detroit, discussing sources of error in the determination of the principal constituents of soda-lime glasses and giving a recommended method for analysis. E.J.V.

Silverman on glass bulb experiments. ALEXANDER SILVERMAN. *Nat. Glass Budget*, **42** [44], 10(1927).—A discussion of the development of bulbs, such as the Crooks' bulb, Roentgen rays, X-ray bulbs, and the electric light bulbs. E.J.V.

A glass factory in the days of Nebuchadnezzar. A. E. MARSHALL. *Nat. Glass Budget*, **42** [45], 3(1927).—Published through courtesy of M. and the AMERICAN CERAMIC

SOCIETY. A historical discussion of the origin of glass, placing it two thousand years prior to the alleged origin in Phoenicia. A description of a glass factory at Nineveh, during 668–626 B. C., made available by the translation of cuneiform tablets by R. Campbell Thompson, is given. E.J.V.

What is the effect of oxidation and reduction on the color produced in glass by selenium? ALEXANDER SILVERMAN. *Nat. Glass Budget*, **42** [45], 9 (1927).—An abstract of this paper delivered at the AMERICAN CERAMIC SOCIETY meeting at Detroit. Agents which reduce selenium produce a series of colors of amber in lead glasses and yellow to red in zinc-lime, potash-soda glasses due to the subsequent solution of the reduced selenium to form polyselenides. Under oxidizing conditions colors from amber to pink are produced due probably to direct formation of polyselenides. E.J.V.

Pyrex industrial glass products offered by Corning Glass Works. ANON. *Nat. Glass Budget*, **42** [45], 23 (1927).—Perfection of qualities in Pyrex glass which meet many exacting requirements make it available for use in industrial processes which demand apparatus possessing difficult combinations of properties. E.J.V.

Hundred years of glass making. ANON. *Pottery Gaz.*, **52** [597], 472 (1927).—A brief discussion of Molineaux, Webb & Co., Ltd., of Ancoats, Manchester, a firm of glass makers 100 years old and still doing business though the industry in that locality has declined. E.J.V.

Technical control in mass production glassworks. ANON. *Pottery Gaz.*, **52** [597], 475–80(1927).—The stiffness of competition among glass manufacturers in England makes technical control an essential for the survival of a business. The importation of modern methods into the industry has made close control of operations necessary. The disadvantages of mechanical production such as the inability of a machine to automatically adjust itself to meet any emergency which may arise are pointed out. The introduction of automatic forming machines means a softening of the batch. The types of glasses which may be worked in the different types of bottle machines are discussed and analyses of various glasses are given. Greater purity of raw materials in order to keep a low iron content is necessary. Judicious buying of raw materials is another aspect of the subject. Three varieties of sand which are used for flint glass in England are discussed as to iron content, cost, and methods of mixing sands to reduce the cost but retain a low iron content. Requirements set by buyers of colored glass must be rigidly lived up to in order to sell well. Careful operation of furnaces at correct working temperatures will aid in improving not only the production figure but also the life of the furnaces. Care not to mix various processes and glasses is another essential to good production. Conducting the buying department under the guidance of analytical control is essential in large works using very large quantities of raw materials. A résumé of analytical requirements for technical control is given. The use of pyrometers, CO_2 recorders, and other instruments is discussed. E.J.V.

Chemical resistance of glasses. G. KEPPELER. *Oesterr. Chem.-Ztg.*, **29**, 227 (1926).—In soda-lime-series of glasses the resistance to solvent action of H_2O and acids decreases rapidly with increased Na_2O content and rises slowly with increasing CaO content. Al_2O_3 reduces the solubility of glass, especially in those of high alkali content. Chemical resistance to H_2O should be distinguished from that toward acids and alkalis. (*C. A.*)

Jena glass. P. H. PRAUSNITZ. *Chem.-Ztg.*, **50**, 941–42(1926).—A historical sketch of the early activities of the Jena glass industry, with a description of the special glasses of recent development. (*C. A.*)

Electric melting of glass. BJOERN RAEDER. *Tek. Ukeblad*, **73**, 336–37, 343–45 (1926).—Many common rocks contain alkalis and other constituents of glass mass in approximately the right proportions. Such masses, however, would require a higher

temperature in the glass furnace, and consequently should be suited for electric smelting. R.'s electric resistance furnace has been tried out on an industrial scale at a Norwegian glass works. Operation under conditions obtaining there was 50% cheaper than in the ordinary glass furnace with coal as fuel. The electric furnace is cheaper in construction and requires less labor for its operation. (*C. A.*)

Notes on sands used in glass making. W. SINGLETON. *Chem. Age*, **15**, 368(1926)—Reference is made to the work of Boswell and Peddle on the characteristics of British glass sands. For glass manufacture a sand should contain not less than 98% of silica. The iron content should be low, and lime and magnesia should be present only in traces. Alumina is sometimes desirable in a glass sand. The sand should be of uniform grain size, preferably between 0.25 and 0.50 mm. diameter. The chief chemical and physical properties of Fontainebleau sand are given. The tentative specifications of the AMERICAN CERAMIC SOCIETY for glass sands are stated briefly. (*Trans. Ceram. Soc.* [Eng.])

Glass capable of withstanding abrupt changes of temperature, mechanical shock, and chemical action. H. KÜHL. *Glashütte*, **56**, 743(1926).—The manufacture and properties are discussed in detail. (*Trans. Ceram. Soc.* [Eng.])

Simple weathering test for glasses. F. SPÄTE. *Glastech. Ber.*, **3**, 127(1925).—Glasses are subjected, at room temperature, to the action of an atmosphere of CO_2, saturated with water vapor. This causes swelling, hydrolytic decomposition, and the formation of carbonates. (*Trans. Ceram. Soc.* [Eng.])

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Glass-feeding mechanism. A. N. CRAMER. U. S. 1,618,271, Feb. 22, 1927. In an apparatus for delivering charges of molten glass, the combination of a container for the glass having an outlet opening in the bottom thereof, a regulating plug projecting downward into the glass over the opening, a horizontal yoke carrying the plug, a member extending lengthwise of the yoke and having a connection at one end with one end of the yoke, a manually adjustable connection between the yoke and the member at their opposite ends, and a driving element connected to the member for moving the plug up and down. In an apparatus for delivering charges of molten glass, the combination of a container for the glass, the container having a discharge opening through which the glass issues, a controlling device extending into the glass, means for reciprocating the controlling device toward and from the opening, including a cam, the cam comprising sections operable to move the device by a series of steps in one direction, and means for adjusting the sections to adjust the relative timing of the step movements.

Glass feeder. L. D. SOUBIER. U. S. 1,618,313, Feb. 22, 1927. In a glass feeder, the combination of a receptacle for molten glass having an outlet opening in the bottom thereof, a vertical plunger projecting into the glass over the outlet, means for periodically reciprocating the plunger vertically, a tubular member mounted on the stem of the plunger, a nonreciprocating gear surrounding the member, means for continuously driving the gear, and a spiral cam on the member operative by the reciprocation of the plunger to effect a relative rotation of the gear and plunger to thereby vary the speed of rotation of the plunger in synchronism with the reciprocating movements thereof.

Apparatus for handling glassware. G. E. HOWARD. U. S. 1,618,660, Feb. 22, 1927. Apparatus for handling and heat treating glassware, comprising a leer, a leer conveyer, and means for alternatively heating or cooling the ware placed on the conveyer, previous to subjecting the ware to heat treatment within the leer.

Making blown-glass articles. E. E. BARTLETT. U. S. 1,618,747, Feb. 22, 1927. Apparatus for making blown glass articles having an appended portion with an enlargment thereon including a one-piece blow mold having an opening of sufficient

size to permit passage of the appended portion and its enlargement therethrough and means for surrounding the projecting portion of the article when the article is positioned in the blow mold so as to substantially close off the opening during the blowing operation.

Guiding device for molten glass. VERGIL MULHOLLAND. U. S. 1,619,432, March 1, 1927. Apparatus for controlling the delivery of mold charges to a mold, comprising a plurality of relatively movable guiding members for the charges, one of the members being arranged to be moved by the mold and to thereby actuate another of the guiding members, to maintain them in proper alinement with each other.

Process of flattening window glass shawls. HOWARD L. HALBACH AND JOHN A. SWEET. U. S. 1,620,017, March 8, 1927. The process of flattening a bent sheet which is a part of a cylinder of glass, which consists in supporting it upon a flattening stone exposed to a degree of heat such as to bring it to flattening condition, applying pressure to the upper face of the sheet to partially flatten it, giving it a motion of translation between a series of opposing parallel members to flatten it while still maintaining it at a temperature at which it may be permanently flattened without marring its surface, and continuing such movement of translation between the members and thus holding it flat while the sheet is cooling until it sets permanently in flat form. The process of completing the flattening of a partially flattened sheet of glass heated to flattening temperature which consists in giving the sheet a motion of translation and during such movement applying rolling pressure to the sheet on opposite sides to completely flatten it while still maintaining it at a temperature such that it may be permanently flattened without marring its surface, and continuing such movement of translation of the sheet while exposed to the rolling pressure while the sheet is cooled until it sets permanently in flat form.

Method and apparatus for feeding molten glass. G. E. HOWARD. U. S. 1,620,207, March 8, 1927. The method of producing mold charges of molten glass by centrifugal force, that comprises receiving a descending stream of glass in a heated receptacle having a discharge opening in the bottom thereof, and controlling the flow of glass from the receptacle by rotating the receptacle at periodically varying speeds to set up centrifugal forces in the glass.

Glass working machine. ALEXANDER SAMUELSON. U. S. 1,620,292, March 8, 1927. In a glass working machine, the combination of a vertical support, a blow-head-support pivoted on the support and vertically movable thereon, a blow-head carried by the blow-head-support, a cylinder-and-piston unit connected to the blow-head-support, to produce vertical movement thereof, a cylinder-and-piston unit connected to said blow-head-support to produce swinging movement thereof, supply pipes leading to the 2 cylinder-and-piston units, means for controlling flow of motive fluid therethrough, and intermediate connections between the 2 cylinders and controlled by the relative movement of their pistons whereby successive lateral and vertical movements of the blow-head are obtained.

Manufacture of glass articles. WILLIAM WESTBURY AND P. W. COLLINS. U. S. 1,620,308, March 8, 1927. The method of manufacture of glass articles, which consists in supplying molten glass to a pot, drawing and severing the article therefrom, then reheating and discharging the glass residue, and axially turning the pot during the reheating operation.

Carrying-in device for leers. E. R. ODOM. U. S. 1,620,778, March 8, 1927. The combination with a leer having an intermittently movable conveyer and an article support in front of the leer, of automatically operating means successively engaging a plurality of the articles on the support, carrying a plurality of articles into the leer, depositing the articles in the leer in a line, returning to its initial position, and again engaging a second lot of articles. A carrying-in mechanism of the character described

including a supporting structure, a beam extending therefrom, the beam and the supporting structure being provided one with a ball and the other with a socket receiving the ball whereby the beam may move laterally in a horizontal plane and vertically, a carrier mounted on the beam for longitudinal movement therealong, ware-engaging members mounted on the carrier, means for reciprocating the carrier on the beam and operating said ware-engaging members, and means for giving the beam a step by step motion in one direction and after a predetermined number of steps returning the beam to its initial position.

Method and device for manufacturing plate glass. LAMBERT VON REIS. U. S. 1,621,144, March 15, 1927. The method of manufacturing plate glass, which consists in rolling the glass mass into plates with flutes on at least one of their surfaces, depositing the plates with a fluted surface on a conveyer having a supporting face provided with flutes in a direction different from the direction of the flutes on the glass plates, and carrying the latter by means of the conveyer to an annealing kiln.

Glass-working machine. J. T. FAGAN AND JOHN J. MALLOY. U. S. 1,621,359, March 15, 1927. In a glass working machine, means for holding each end of a glass tube blank, means for successively advancing a series of the holders, means for alineing the blanks relative to each other, means for continuously and synchronously rotating the holders during their advancement, means for heating the rotating blanks locally and means for applying a gradual pull longitudinally of the heated blanks whereby a contraction is formed on each of the blanks.

Apparatus for producing mold charges of molten glass. W. J. MILLER. U. S. 1,621,426, March 15, 1927. In apparatus for feeding molten glass in a succesion of mold charges, the combination with a receptacle for molten glass provided with a discharge outlet, of a vertically reciprocating implement working in the glass in the receptacle to control the discharge of glass through the outlet without seating at the outlet, means for imparting a reciprocating movement to the implement, means for limiting the reciprocating movement of the implement comprising an element moving in unison with the implement and adjacent to an abutment, and adjustable stop members at opposite sides of the abutment to limit the motion of the element relative to the abutment.

Producing glass suited particularly for insulating purposes. ANON. Eng. Pat. 256,189, June 11, 1926. A glass for insulating purposes contains silica, potassium oxide, and one or more oxides of bi- or tervalent metals, and is prepared from a batch containing no reducing agents, but which contains iron oxide as an auxiliary flux, and is melted in an oxidizing atmosphere. (*Brit. C. A.*)

Electric furnaces [for glass]. J. K. B. RAEDER, AND AKTIESELSKABET RAEDERS ELEKTROGLASOVN. Eng. Pat. 262,535, Sept. 17, 1925. Solid electrodes wholly submerged in a bath of molten glass which acts as a resistance to the electric current are provided with a surface sufficiently large to reduce the current density and to ensure that the electrodes are outside the actual heating zone of the bath, thereby improving the appearance of the glass produced. (*Brit. C. A.*)

Electric furnace for melting and heating glass. FASTIGHETSAKTIEBOLAGET DE CARNEGIE & CO. Swed. 60,726, May 4, 1926. The heat is produced by resistance elements made from materials that are not oxidized or attacked by the glass at 1400°. Features of construction are described. (*C. A.*)

Heavy Clay Products

Draft comparison of cement and clay gas flues. A. LEE BENNETT. *Jour. Amer. Ceram. Soc.*, **10** [3], 220-23 (1927).—The purpose of this investigation was to obtain comparison of cement and clay flues.

Brick-wall investigation. ANON. Bur. Stand., *Tech. News Bull.*, No. 118, pp. 1–2 (1927).—First section of investigation deals with properties of individual bricks of 4 typical types. Second section consists in the construction and test of walls. Correlation of these results will give information directly applicable to the formulation of standards and specifications for brick. The program consists of tests on 153 walls divided into 4 series. The variables consist of 2 types of workmanship, 4 kinds of clay brick, 3 kinds of mortar, and different types of construction covering 8- and 12-inch solid walls and the various 8- and 12-inch hollow walls used by the C.B.M.A. Descriptions of walls, types of mortars, and a number of conclusions are given. R.A.H.

90% of the tile market is lost. LEE H. MILLER. *Brick Clay Rec.*, **70** [4], 267–68 (1927).—M. points out some of the faults of concrete which has supplanted tile. F.P.H.

Chicago welcomes C.B.M.A. ANON. *Brick Clay Rec.*, **70** [4], 269 (1927).—Program of the annual convention of the Common Brick Manufacturers Association. F.P.H.

Greatest clay machinery shown. ANON. *Brick Clay Rec.*, **70** [4], 270–73(1927).—Description of exhibits of the 1927 clay machinery exposition to be held at Chicago, Feb. 21–26, 1927. F.P.H.

How Bryan makes his brick. ANON. *Brick Clay Rec.*, **70** [4], 294–96(1927).—Description of the plant of the Mercier-Bryan-Larkins Brick Co. Automatic machines, clay cleaners, steam driers, oil burning, and modern methods used throughout. F.P.H.

Metropolitan designs new product for sewage filtering. CHARLES G. REED. *Brick Clay Rec.*, **70** [4], 297–98(1927).—A vitrified floor system for trickling filters for sewage disposal plants which, it is claimed will last practially indefinitely and is much lower in original cost than the concrete formerly used for such purposes, has been perfected by the Metropolitan Paving Brick Co. This system is being installed in the sewage disposal plant being constructed in Akron, Ohio. F.P.H.

Finzer's triple capacity. ANON. *Brick Clay Rec.*, **70** [5], 378–85(1927).—A description of the plant of the Finzer Brothers Brick Co. F.P.H.

A half-million dollar plant operated without clutches. ANON. *Clay-Worker*, **87** [3], 197–202(1927).—A description of the face brick factory of the Finzer Brothers Clay Company located at Sugarcreek, Ohio. There is not a single clutch on the entire plant. It is electrified throughout, synchronized motors with Tex Rope Drives being used. F.P.H.

Factory design and equipment. T. W. GARVE. *Clay-Worker*, **87** [3], 204–309(1927). —The 2nd of a series of articles on this subject. This article deals with general factory arrangments. Fifteen flow sheets for the manufacture of heavy clay products are given. These flow sheets list the various machines, with some auxiliary equipment, in the proper order. The particular type of equipment necessary for certain process is determined by the nature of raw material to be handled and the kind of product desired. F.P.H.

Work of the Fire Underwriters Laboratories on rock products. ANON. *Rock Products*, **30** [4], 35(1927).—The following subjects are considered: (1) standard specifications for fire tests, (2) hollow concrete blocks, (3) wall boards, (4) gypsum plaster. F.P.H.

Composition and structure of fired bricks. E. DONATH. *Tonind. Ztg.*, **49**, 1204 (1925).—Analyses of fired building bricks showed that the red color was due not merely to the iron oxide content, but also the ratio between it and silica and lime. The binding power of mortar is considered to be due to an adhesion process coupled with chemical reaction. (*Trans. Ceram. Soc.* [Eng.])

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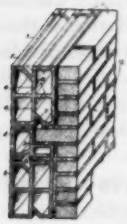
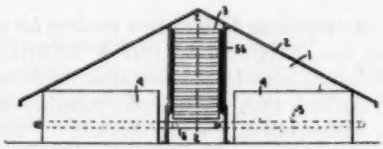


Building block and wall construction. R. F. GREENE. U.S. 1,618,426, Feb. 22, 1927. A hollow building block having 2 bearing sides, a channel dividing each of the sides, each of the channels having 2 side walls disposed at an angle with respect to each other to form a V, and a flat web connecting the bearing sides of the block, the web constituting one of the side walls for each of the channels.

Wall construction and building block. R. F. GREENE. U. S. 1,618,281, Feb. 22, 1927. A hollow building block having a flat bearing side and an offset bearing side parallel therewith and parallel with the hollow space in the block, a web normal to the bearing sides and directly connecting therewith, the web dividing the hollow space in the block into parallel air spaces, and an air channel located in the flat bearing side parallel with the air spaces, the channel consisting of 2 walls disposed at an angle with respect to each other to form a V, the web serving as one of the walls, the other wall directly connecting the flat bearing side at one edge of channel with the web at the bottom of the channel.

Apparatus for producing brick. L. L. DENISON AND G. W. DENISON. U. S. 1,618,582, Feb. 22, 1927. In an apparatus of the character described, the combination of a firing kiln for bricks, a drier positioned adjacent said kiln and extending to a higher elevation than the tops of the kiln, and means for deflecting the heated gases from the kiln through said drier. In an apparatus of the character described, the combination with a clay column extruding device, means for severing a section from the clay column, a transferring table for receiving the section, means for moving the transferring table transversely, and means for subdividing the severed section of clay column upon transverse movement of the transferring table.



Burning clay bricks in annular kilns. F. ANDERSON. Swed. 60,608, April 13, 1926. Mechanical features regarding the way of placing the bricks are described. (*C. A.*)

Refractories

Variations in softening points of refractory materials due to rate of heating. S. S. COLE. *Jour. Amer. Ceram. Soc.*, **10** [3], 180–84 (1927).—Results are given of a series of softening point tests upon several types of refractory materials in which the rate of heating to obtain cone 28 down was varied from one hour to five hours. The results are presented in order to show that much of the data obtained by a fusion furnace is dependent upon the rate at which the furnace is heated and that large variations will occur unless care is taken to duplicate conditions of previous tests. Conclusions reached were: that two laboratories must duplicate the essential conditions in order to obtain agreement, that the furnaces should be of the same type and heated in a similar manner, that the variations reported by different investigators can often be traced to the fact that conditions have not been duplicated.

The development of clay mining. J. GOMBERT. *Tonind. Ztg.*, **50**, 50th Anniv. No., p. 26(1927).—Considerable progress has been made in the developement and use of German clays during the last 50 years. For example, the Klingenberg clay is used in many foreign countries in addition to Germany for crucibles. Also grossalmerode clay is used for glass refractories in all the civilized countries in the world. Also the well known Meissen clay is used for fine ceramics and in the glass industry. The

Rausker clay is used in Schlesien for the zinc industry and last but not least the Westerwalde clay, which has been used for pipes for many years is also used for finer ceramic products in Germany and abroad, especially in the tile industry. The clay from Rheinpfalz has been used extensively especially in foundries and also the Neuroder Beckens clay has a world wide reputation for refractories. H.G.S.

Refractory properties of commonly used oxides. J. BROWN. *Feuerfest*, **2** [11], 105 (1926).—Improved testing furnaces devised to do this work. Melting points established of following mixtures: (1) alumina-silica, (2) lime-silica, (3) magnesia-silica, (4) lime-alumina, (5) magnesia-lime, (6) lime-iron oxide, (7) magnesite-kaolin, (8) kaolin-titanium oxide, (9) kaolin-chrome compounds. Further tests covered mixtures of 3 or more components such as: (1) lime-alumina-silica, (2) magnesia-alumina-silica, (3) magnesia-lime-silica, (4) magnesia-lime-alumina, (5) well-known clays-zirconium oxide. Photographs of plastic diagram models, graphs, and triaxial diagrams illustrate the article. F.A.W.

Refractory materials for coking chambers and gas works. L. LITINSKY. *Feuerfest*, **2** [11], 101 (1926).—Classification of fire brick. Suitable materials for use under these conditions and some properties of the raw materials used are discussed. Comparison of properties of basic, neutral, and silica brick under service conditions and a slight preference shown for the latter. F.A.W.

Open-hearth furnace refractories. W. TRINKS. *Fuels and Fur.*, **5** [2], 175–76 (1927).—The most desirable material for open-hearth refractories would combine (1) considerable compressive strength and resistance to spalling with (2) immunity to chemical influences (lime and iron vapors). No such material is available so a compromise must be made in choosing materials to meet certain conditions. To obtain sufficient cool material to bear the load in a furnace the walls must be thin or water-cooled. Silica bricks are used to carry loads or in arches, even in basic furnaces. Chromite bricks are used for moderate loads and to form a neutral layer between the basic hearth material and the acid bricks of the roof and front-wall piers. Magnesite is much used for bottoms and for sloping walls that can be patched. Fire brick are excellent for the substructure of open-hearth furnaces. Great strength is not required for furnace bottoms, although the hot steel tends to work soft spots in the bottom and lift semiloose portions by ferrostatic pressure. Dolomite is used for hearths. It would float on the steel if it were not sintered in place and is attacked by sand if dirty scrap or pig iron is used. Zirkalite, which is zirconium oxide with a binder, has been used recently to paint brick work and exposed iron piping. A.E.R.W.

Requirements of refractories for manufactured-gas plants. II. SANFORD S. COLE. *Fuels and Fur.*, **5** [2], 221–22 (1927).—A discussion of the different types of vertical and horizontal retorts, of the properties which they should possess and the mortars which should be used in setting them. The kinds of refractories used, the specifications which should be used, and the conditions which the refractories must meet in practice are described. A.E.R.W.

Solid solution in the spinel minerals and its relation to their use in refractories. ANON. Bur. Stand., *Tech. News Bull.*, No. 118, pp. 5–6 (1927).—Magnesium spinel has certain properties desirable in a refractory material but due to the formation, at high temperature, of solid solutions with various oxides, it also has serious shortcomings. An investigation covering these phenomena has been undertaken. Outline of procedure of study is given and some results noted. R.A.H.

Proposed specifications for clay fire brick for malleable furnaces with removable bungs and for annealing ovens. ANON. *Proc. A. S. T. M.*, **26** [1], 249–52 (1926).—The purpose of these specifications is the selection of clay fire brick that are suitable for

service in malleable furnaces under general conditions of operation and furnace design. The factors which affect the life of the brick are classed as follows: (*a*) those dependent upon fuel or firing, (*b*) those dependent upon furnace design or construction, (*c*) those dependent upon character of charge, (*d*) those dependent upon operating conditions. The specifications cover (1) scope; (2) size tolerance; (3) test requirements, (*a*) bungs, (*b*) sidewalls and bridgewalls, (*c*) firebox linings and lower stack linings, (*d*) upper stack lining, (*e*) annealing oven firebox, (*f*) annealing oven chamber, (*g*) methods of testing. R.A.H.

Industrial survey of conditions surrounding refractory service in the copper industry. ANON. *Proc. A. S. T. M.*, **26** [1], 253–63 (1926).—This survey covers the smelting and refining of sulphide copper ores. Types of furnaces used in both smelting and refining are described, together with refractories used in the different sections of the furnaces. A table is included which gives a classification of refactories for the copper industry. R.A.H.

Industrial survey of conditions surrounding refractory service in the lead industry. ANON. *Proc. A. S. T. M.*, **26** [1], 264–68 (1926).—This survey describes the smelting and refining of sulphide lead ore. A table giving a classification of refractories for the lead industry is included together with some remarks affecting the life of the refractories used. R.A.H.

Industrial survey of open-hearth practice. ANON. *Proc. A. S. T. M.*, **26** [1], 269–76 (1926).—A brief description of the production of steel by the open-hearth process is given. A discussion on the types of refractories is included as well as a table on the analysis of service conditions in producer-gas fired stationary open-hearth furnace. This table covers location of brick in furnace, type of material, temperature, slagging action, abrasion, load, spalling. R.A.H.

A study of the spalling test for fireclay brick. M. C. BOOZE. *Proc. A. S. T. M.*, **26** [1], 277–80 (1926).—A general discussion with some experimental data to show the difference in results obtainable with different brands of brick when reheated at various temperatures and subjected to the spalling test by quenching in running water from 850°C and immersing the brick either 1, 2, or 4 inches. R.A.H.

Fractional melting of refractory materials. ANON. *Ciment*, **31** [5], 185–86 (1927); *Stahl u. Eisen*, **46** [58], 1717 (1926). F.P.H.

A method for the quantitative determination of the action of slag and flue dust on refractory brick. F. HARTMANN. *Ber. Werkstoffausschuss Ver. deut. Eisenhüttenleute* No. 81 (1926); *Stahl u. Eisen*, **47** [5], 182–86 (1927).—The slag tests that have been used are discussed. A new type of slag test is described. The apparatus consists of a carbon resistance furnace with a vertical tube of refractory material running through the furnace. In this tube is placed the test piece (30 mm diameter by 30 mm in height) supported by a rod. The slag is fed from the top through a quartz tube fitted with a funnel. The furnace and test piece is raised to the desired temperature and about 40 grams of slag are fed slowly on to the test piece. The addition to the slag requires about 30 minutes. The temperature is maintained for 15 minutes longer and then allowed to cool. The percentage change in volume and weight is then determined. The tests can be carried out under either oxidizing or reducing conditions. Influence of temperature and pressure is studied. The porosity and firing temperature of the refractory is also considered. The slags used were those encountered in the metallurgical industry. The action of those slags on the common refractories was studied. F.P.H.

The structure of silica brick used in coke ovens. K. ENDELL AND E. PFEIFFER. *Ber. Werkstoffausschuss Ver. deut. Eisenhüttenleute*, No. 91 (1926); *Stahl u. Eisen*, **47** [3], 99–100 (127).—The requirements of silica brick for coke ovens is different from

those for the Siemens-Martin furnace. In the former it is desirable to have a very small expansion over the range from 1400 to 1500°C. In the latter the refractory is required to stand a higher temperature. There are 2 types of expansion found in this type of material: (1) permanent expansion caused by the irreversible changes that quartz undergoes on heating; (2) temporary expansion caused by the reversible changes of the various forms of silica. Forty-one bricks consisting of 6 brands of German, 1 of English, and 1 of American manufacture were tested. Typical expansion curves are given for correctly fired brick. A good silica brick should show a considerable temporary expansion at from 200–300°C and no quartz transformation at 575°C. The following specifications for silica brick for coke ovens are suggested: (*a*) The true specific gravity should not be greater than 2.40, (*b*) the softening point under a load of 2 kg/cm should not be lower than 1550°C, (*c*) the measurement of the temporary expansion of the brick should not show a quartz transformation between 500 and 600°C. F.P.H.

Investigation of the load test for and the expansion of silica brick. HANS HIRSCH. *Ber. Werkstoffausschuss Ver. Eisenhüttenleute*, No. 93 (1926); *Stahl u. Eisen*, **46** [48], 1717 (1926). F.P.H.

Recent advances in electrochemistry. COLIN G. FINK. *Min. and Met.*, **8** [242], 52–55 (1927).—Increasing use of electric furnaces calls for better refractories. The best lining material today which is universally used is magnesium oxide. A lining of pure magnesium oxide can be operated at temperatures of only about 2200°C. The temperature of the arc in the electric steel furnace is about 4000°C or considerably above that temperature that the lining will stand. Equimolecular parts of thoria and zirconia produce a refactory that has a melting point of 3000°C but the price of this refactory is still prohibitive. F.P.H.

The testing of refractory material and its behavior in metallurgical operations. E. H. SCHULZ. *Stahl u. Eisen*, **46** [47], 1667–78 (1927).—An address delivered before the German Metallurgical Society Nov. 27, 1926. The requirements of a refractory are determined by the type of furnace in which the material is to be used. Certain of the following factors determined the suitability of a refractory for the various metallurgical operations: (1) melting point, (2) refractoriness; (3) resistance to temperature changes, (4) constancy of volume, (5) heat conductivity, (6) elasticity of compression, (7) resistance to abrasion, (8) resistance to chemical action. S. indicates by means of a chart which of the above factors are important in selecting refractories for the different types of metallurgical furnaces. The following tests are suggested to give information in regard to the above factors: (1) pyrometric cone equivalent, (2) analysis, (3) structure, (4) specific gravity, (5) porosity, (6) expansion, (7) heat conductivity. F.P.H.

The question of the requirements of refractory materials. HEINE KORNFELD. *Stahl u. Eisen*, **46** [50], 1790–94 (1926).—The question of slag action is considered. Diagrams showing the temperature distribution obtained in various refractories heated to different temperatures are given. Heat insulation is considered. F.P.H.

The effect of oxide impurities upon the physical properties of silica brick. K. ENDELL AND R. HARR. *Stahl u. Eisen*, **46** [52], 1870–76 (1926).—The following oxides are added to silica: lime, alumina, iron oxide in amounts varying from 2 to 6%. Mixtures of alumina and iron oxide, alumina and lime, iron oxide and lime are also added to silica. The effect of these impurities on the following properties are studied: (1) true specific weight, (2) microstructure, (3) expansion between 100 and 1000°C, (4) porosity, (5) mechanical strength at room temperature, (6) softening temperature under a load of 1 kg/cm^2. All of the impurities increase the true specific gravity. A microscopic examination shows that the alumina does not increase the amount of quartz transformed to the higher temperature forms. Lime favors the formation of tridymite and leads to the formation of calcium silicate. Iron oxide accelerates the formation of tridymite.

The expansion curves with the alumina mixtures show the cristobalite effect at 230°C and the quartz effect at 575°C. The iron oxide produces a strong cristobalite and tridymite effect between 100 and 300°C but no quartz effect. The mechanical strength is increased by Fe_2O_3 and very little affected by Al_2O_3 and CaO. The softening temperature under load is not affected very much by CaO and Fe_2O_3, but is lowered by Al_2O_3. The following recommendations are made: (*a*) the alumina content should not exceed 1.5%, (*b*) a total lime content of 8% is without influence on the softening temperature under load and increases the transformation of quartz into tridymite, (*c*) iron oxide increases the tridymite content and up to 4% is without influence on the softening temperature under load. A reducing atmosphere would be harmful to such brick. F.P.H.

Various uses of vitreous silica and vitreous quartz. W. W. WINSHIP. *Amer. Glass Rev.*, **46** [21], 37(1927); reprinted from *Fuels and Fur.* See *Ceram. Abs.*, **6** [2], 66(1927). E.J.V.

New refractory cement. ANON. *Amer. Glass Rev.*, **46** [22], 20(1927).—A new high temperature cement, basically composed of chromite, with no sodium silicate or other quick-setting elements, having a fusion point over 3500°F and a tensile strength of over 300 lbs. per sq. in., has been placed on the market by the General Refractories Co. It is of neutral character, resisting both acid and basic slags. E.J.V.

Highly refractory materials. BACH. *Centralblatt der Hutten und Walzwerke*, **30** [22], (1926).—A discussion of "Martinit" and "Aluminit," refractories produced by a German concern, which have an original firing temperature of 1420°C, a melting point of Seger cone 38–40, and are very resistant to slag action. Photographs of arches in boilers of these refractories show no signs of failure after 2000 hours firing, while fireclay refractories are in poor shape after a similar treatment. E.J.V.

Tank block endurance. S. R. SCHOLES. *Glass Indus.*, **8** [3], 61–62(1927).—The recent development of mullite tank block is discussed. Solubility of all oxides in glass makes it difficult for the chemist to choose a final material for tank blocks. The significance of the work of Bowen and Greig on the alumina-silica system is emphasized and its teachings discussed from a physicochemical standpoint. The ideal characteristics of mullite block are mentioned and no doubt of their endurance is maintained. E.J.V.

Clay pots made by the Willets Company backed up by 57 years of experience. ANON. *Nat. Glass Budget.*, **42** [43], 3(1927).—A historical account of the founding and growth of the Willets Co. of Pittsburgh, Pa., makers of fine quality clay glass pots. E.J.V.

Sillimanite and cyanite (India). ANON. *Bull. Imperial Inst.*, **24**, 761(1926).—Although the use of sillimanite as a refractory is yet only on a very small scale, a great deal of experimental work is being done on it, owing to the discovery of the mineral in quantity in the Khasi Hills, Assam. Cyanite was discovered in 1921 in the Singhbhum copperbelt, in masses of various sizes up to hills containing many thousand tons. Cyanite changes to sillimanite at a temperature of 1300°C, and expands 11% in volume on heating. For these reasons it is possible that a large demand may arise for cyanite as a refractory material. O.P.R.O.

Studies on diaspor. YOHEI YAMAGUCHI, TOSHIMASA TAKEBE, AND TOICHI MORIOKA. *Bull. Inst. Phys. Chem. Research*, **5**, 17–31(1926).—By the dynamical method, the vapor pressure of water produced as a decomposition product of diaspor according to the formula, $Al_2O_3.H_2O \rightarrow Al_2O_3 + H_2O$, against temperature is measured; the composition of the sample is H_2O 14.78, Al_2O_3 83.80, and SiO_2 1.42%. The temperature at which the vapor pressure of water is produced by the decomposition of diaspor is 502.5°. The Clapeyron-Clausius' formula is applicable to the relation between the vapor pressure (π) above mentioned and absolute temperature (T) and there is a linear

relation between log π and $1/T$. The heat of decomposition of diaspor at about 500° calculated by that formula is 353 cal./kg. or 0.411 kw. hr./kg. The specific heat of diaspor is measured at 100–400° and the mean specific heat is expressed as $c' = 0.2085 + 0.000127t$. The total energy required for changing diaspor into Al_2O_3 by heating at 502.5° is calculated to be 486.7 cal./kg. or 0.5666 kw. hr./kg. (*C. A.*)

Properties of bauxite. YOHEI YAMAGUCHI, TOSHIMASA TAKEBE, AND TATSUJI YAZAWA. *Bull. Inst. Phys. Chem. Research*, **5**, 735–40 (1926).—By the dynamical method vapor pressures of bauxite against temperature (230–518°) are measured; the composition of the sample is SiO_2 5.4, Al_2O_3 62.0, Fe_2O_3 10.7, and H_2O 22.0%. The decomposition of bauxite by evolving H_2O occurs in 2 stages: $Al_2O(OH)_4 \rightarrow Al_2O_2(OH)_2 + H_2O - Q_1$, and $Al_2O_2(OH)_2 \rightarrow Al_2O_3 + H_2O - Q_2$. The vapor pressures ($\pi$) of the decomposition of the first (at 200–340°) and second (at 350–450°) stages are expressed by $\log \pi = 6.5277 - 2206.5/T$ and $\log \pi = 5.2566 - 1780/T$ respectively. For comparison, vapor pressures of $Al(OH)_3$ and $Fe(OH)_3$ obtained by precipitation are measured without concrete conclusion. The heat of decomposition of bauxite is calculated from the Clapeyron-Clausius' formula: Q_1 (200–340°) = 10100 cal./mol., and Q_2 (350–450°) = 8100 cal./mol. (*C. A.*)

Some dolomites. NICHOLAS KNIGHT. *Proc. Iowa Acad. Sci.*, **32**, 322 (1925).—The composition of 15 specimens examined corresponds to previous reports, namely, that specimens of rock called dolomite vary over rather wide limits. (*C. A.*)

Studies on the properties of diaspor and bauxite. YOHEI YAMAGUCHI AND TOSHIMASA TAKEBE. *Bull. Chem. Soc. Japan*, **1**, 240–44 (1926).—The vapor pressures of diaspor can be calculated by the following equation for 400–500°: $\log \pi = 14.820 - 9255.1/T$. The decomposition-pressure curve of bauxite consists of 2 parts. At 200–340°, $\log \pi = 6.5277 - 2206.5/T$, and at 350–450° roughly $\log \pi = 5.2566 - 1780/T$. The specific heat of diaspor by the calorimetric method gave $c = 0.2085 + 0.000127t$. (*C. A.*)

A new process for the preparation of alumina from natural silicates. HEINRICH KASSLER. *Chem.-Ztg.*, **50**, 917 (1926).—Under Czechoslovakian Patent 18,648, Lederer and Stanczak describe a process for obtaining Al_2O_3 from silicates by treatment with soda solution under pressure, and then permitting the mass to cool. $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O + NaCO_3 = Na_2O \cdot Al_2O_3 \cdot 2SiO_2 + CO_2 + 2H_2O$ represents the reaction upon heating; a reverse reaction occurs upon cooling in a closed vessel, with the formation of Al_2O_3 and silicic acid. (*C. A.*)

The refractories industry as a chemical problem. HANS HIRSCH. *Z. angew. Chem.*, **39**, 1437–43 (1926).—With stricter specifications for refractories for special purposes, and with no corresponding improvement in available native raw material, the improvement of the latter by chemical and physical means becomes imperative. Modern methods for applying phase diagrams to study temperatures of softening, the selection and mixing of raw materials, the preparation of refractories from other than naturally occurring silicates, the use of refining processes both wet and dry, testing machines and furnaces employed in ceramic laboratories, photomicrographs, etc. are discussed and illustrated. (*C. A.*)

Carborundum as a refractory material; its increasing use in Germany. B. KLEINSCHMIDT. *Tonind. Ztg.*, **49**, 1377 (1925); *Chem. Age*, **15**, 178 (1926).—The properties of Carborundum and its industrial applications are outlined. Refrax consists of interlocking Carborundum crystals without binding material, carbofrax of silicon carbide and a small quantity of fire clay. Carbofrax is used extensively in side walls, fire bridges, and combustion chambers of oil-fired furnaces; in flues, furnace arches, etc., of porcelain kilns fired with oil. By replacing clay muffles with Carborundum muffles, the Carborundum Gesselschaft claim a fuel saving of 20–75%. (*Trans. Ceram. Soc.* [Eng.]).

Drying and firing silica bricks. ANON. *Corr. dei Ceramisti*, **7**, 73 (1926).—Silica bricks should be dried thoroughly before firing. The most suitable firing temperature is between cones 15 and 16, in order to convert the quartz to tridymite. For Martin furnaces, reaching temperatures of 1700°, bricks should not contain more than 3 to 5% of basic oxides. (*Trans. Ceram. Soc.* [Eng.])

Zircallite, a new preventive against the destruction of furnace linings. M. BERGER. *Feuerungstechnik*, **14**, 254 (1926).—A patent mixture containing zirconia gives excellent protection to grog and silica materials, particularly in powdered coal and oil furnaces, Martin furnaces, etc. When used as mortar it fuses with the brickwork to form a monolithic structure. (*Trans. Ceram. Soc.* [Eng.])

Refractory mortars. V. BODIN. *Ceramique*, **28**, 201 (1925).—A good refractory mortar should be similar in chemical composition and in melting temperature to the refractory material; it should be sufficiently fine to fill joints 3 to 5 mm thick, be sufficiently plastic, have a minimum drying shrinkage and after contraction, and the temperatures at which shrinkage and softening begin should correspond with those of the refractory structure. Methods of testing mortars are based on these requirements. Five different mortars are distinguished, containing less than 10% to more than 45% of alumina. Specifications are given for mortars for small furnaces, and for blast furnaces, metallurgical furnaces, and coke ovens. (*Trans. Ceram. Soc.* [Eng.])

Effect of porosity upon thermal conductivity, diffusibility, and heat capacity at high temperatures. Y. TADOKORO. *Sci. Rept. Tôhoku Imp. Univ.*, **15**, 567–96 (1926).—Refractory materials were prepared from a mixture of 2 pts. (by vol.) of alundum powder (80 mesh/in.) and 1 pt. of washed "Gairome" fire clay, and the porosity was varied by adding increasing amounts of sawdust. The properties of these materials were then examined, and also of specimens made from diatomaceous earth. The porosity and gas permeability vary similarly. The permanent changes in weight and length caused by heating at tempeatures up to 1300° were measured; if diatomaceous earth is heated to 1100° before use, it can subsequently be heated at high temperatures without fear of cracking from volume change. Both thermal expansion and crushing strength decrease with increasing porosity, the curve connecting these constants resembling a rectangular hyperbola. If K is the thermal conductivity, ρ the sp. gr., and C the sp. heat, the diffusibility h^2 is given by $h^2 = K/\rho c$. The effects of porosity on diffusibility, thermal conductivity, and heat capacity have been determined; in all cases a minimum value is given by a porosity of 37–38%. The spalling tendency is expressed by the relation $(\alpha \times \text{crushing strength})/h$, where α is the coefficient of expansion; here, again, a porosity of 37–38% is a critical point which is of importance in the manufacture of fire brick. Diatomaceous earth is a very good insulating material, but its crushing strength is low. (*Brit. C. A.*)

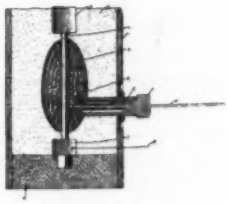
BOOKS

Refractory Materials for the Chambers of Coke Ovens and Gas Producers. L. LITINSKY. 50 pp. Halle (Saale): W. Knapp (1926).—A general classification of refractory materials is given. Under materials for chambers of coal distillation furnaces are discussed: quartzite brick (acid); chamotte brick (basic); and neutral brick using a clay bond with quartz or some other form of silica and chamotte for nonplastic. Chemical analyses of typical examples of all these types are given. Observations on raw materials for refractory brick are presented in a discussion of the various properties of the materials and their behavior under different kinds of treatment. Under requirements of refractory materials to be used in chambers for coal distillation furnaces are: difficult fusibility; stability under load at high temperatures; volume stability at high temperatures, as well as retention of mass; low thermal expansion; resistance to salt attack and slag deposition; thermal conductivity; resistance against abrupt temperature change; low porosity or high density; and mechanical strength. Each of these require-

ments is discussed at length. The repair of chamber walls by a tamping or ramming process is described. The question of silica or chamotte brick is discussed. E.J.V.

The Tertiary Quartzite of Central Germany and Its Importance to the Refractory Industry. B. VON FREYBERG. Published by Fred. Enke of Stuttgart. Reviewed by *Stahl u. Eisen*, **46** [48], 1734 (1926). F.P.H.

PATENTS



Process and apparatus for producing silica articles. H. L. WATSON. U. S. 1,621,446, March 15, 1927. The process of shaping silica which consists in heating a part only of a mass of silica to fusion in such a manner that the unfused silica serves as a support for the fused silica, exerting sufficient traction upon the fused silica in the heating zone to withdraw the same and excluding unfused silica from withdrawal.

Manufacture of refractory articles of pure zirconium oxide. ANON. Eng. Pat. 246,480, Jan. 21, 1926. Pure zirconium oxide obtained from the basic sulphate can be made into refractory articles capable of withstanding temperatures up to about 2600° without shrinkage or cracking by sintering the oxide at above 1800°, working up the articles without particularly fine grinding, and firing in 2 stages, first at about 1300° and subsequently above 2000°. If the mass of zirconium oxide is subjected to pressure the temperature of firing may be lowered to 1600°.

Alumina from natural silicates. ANON. Czechoslovakian Pat. 18,648; *Rock Products*, **30** [5], 74 (1927). Clay, kaolin, or other aluminum silicates are treated with a sodium carbonate solution, pressure applied, and the mixture allowed to cool. After filtration the filter is treated with sulphuric acid to obtain aluminum and iron sulphates. The filtrate is recovered and put back into the process. F.P.H.

Refractory magnesite forms. ANON. Ger. Pat. 437,106; *Rock Products*, **30** [5], 74 (1927). Lime and magnesite low in iron or lime and magnesia are fused in an electric furnace. After cooling and pulverizing, fine ground magnesite is added and the mass again fused and finally poured into molds. F.P.H.

Refractory heat-insulating material. A. J. H. HADDAN. Eng. Pat., 256,021, June 27, 1925. An insulating material, consisting mainly of silica of higher specific gravity than diatomaceous earth, contains: 93 parts of diatomaceous earth, 5 parts of clay, 2 parts of quicklime, mixed with 170–180 parts of water, and is molded under low pressure and fired to 1370°. Most of the silica is converted into tridymite. (*Trans. Ceram. Soc.* [Eng.])

Saggers. F. BENNION AND J. B. CLARKE. Eng. Pat., 255,798, June 15, 1926. Saggers or setters are fitted with one or more rings of nickel alloy or other refractory metal. (*Trans. Ceram. Soc.* [Eng.])

Alumina. A. FINKELSTEIN. Brit. 248,746, March 3, 1925. In extraction of alumina by the Bayer process, the mother liquor after separation of alumina, at a density not higher than 1.36, is used without concentrating to dissolve more alumina, at a temperature of about 170° (the alumina being separated at about 70°). The wash-waters are evaporated to a strength about equal to the mother liquor, or concentrated mother liquor may be added to the wash-waters to bring up their strength. Other details are specified. (*C. A.*)

Refractory material. GROSVENOR SCIENTIFIC PRODUCTS, LTD. AND B. TURNER. Brit. 250,354, Feb. 2, 1925. Chrome ore, crushed to pass through a 0.1 in. mesh, is mixed with china clay and a soluble silicate, and the mixture is molded under pressure and fired. (*C. A.*)

Manufacture of refractory bricks. HOEGANAES-BILLESHOLMS AKTIEBOLAG. Swed. 60,902, June 2, 1926. SiC is mixed intimately with a binding material consisting chiefly of finely divided free SiO_2. (*C. A.*)

White Wares

Some whiteware bodies developed at the Ohio State University. ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **10** [3], 148–49 (1927).—Formulas of bodies and glazes are given which through 10 years of classroom experimenting have proved the best for statuary, electrical, hotel, and chemical porcelain. The conditions and limits of use of carbonates of magnesia and calcium are given.

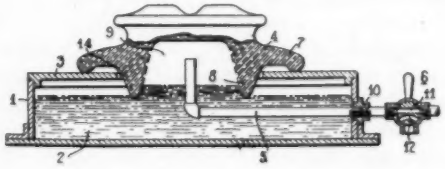
Microstructure of earthenware. ANON. Bur. Stand., *Tech. News Bull.*, No. 118, p. 5 (1927).—Nineteen samples of glazed earthenware bodies varying in composition or in firing treatment were examined microscopically in thin sections and many photomicrographs made. Particular attention was paid to the size of the mullite crystals formed, under different firing conditions, within the body and at the body glaze contact. Conclusions noted: (1) that mullite crystals at the contact of body and glaze grew out from the body into the glaze in a position approximately normal to the contact; (2) that mullite crystals at the contact were always larger than those within the body proper; (3) that, in general, the greater the heat treatment in firing the unglazed ware the longer the mullite crystals within the body and at the contact. R.A.H.

Investigation of feldspar. ANON. *Ceram. Indus.*, **8** [3], 301 (1927).—A survey of the work of the Bureau of Standards on the investigation of the raw materials entering into the compositions of the whiteware bodies and the effects of variations of the raw materials on the qualities of the finished products. F.P.H.

Science in the pottery industry. A. J. DALE. *Pottery Gaz.*, **52** [597], 469–72 (1927). —The manner in which science is slowly getting to the bottom of the peculiarities and troubles of pottery manufacture is reviewed under the following separate topics: raw materials, testing supplies, size of particles, constant grain size, elutriation, slips, slip-making and casting, the casting process, testing alkalis, drying and firing, firing control and fuel economy, and the artistic side of industry. Under each of the subheads is given a fairly concise discussion of the topic. E.J.V.

Contracts awarded for new million-dollar Laughlin pottery. ANON. *Pottery, Glass, & Brass Salesman*, **35** [5], 27 (1927).—A description of unit No. 7 of the Homer Laughlin China Co., to be erected by the Austin Co. This plant is to be equipped with two Harrop tunnel-ware kilns and a decorating kiln also of the continuous type. E.J.V.

PATENT



Method of and means for coating inner surfaces of hollow bodies. R. P. JACKSON. U.S. 1,621,016, March 15, 1927. The method of coating the interior surface only of a member of substantially cup-shape having imperforate walls, comprising placing the mouth of the cup in inverted position over a body of coating liquid so that the liquid seals the mouth and in withdrawing air from the cup.

Equipment and Apparatus

Rubber linings. A. M. MUNRO. *Chem. Eng. Min. Rev.*, **19**, 97–99 (1926).)—Rubber linings for ball mills have many advantages. The lining weight is reduced, saving power for driving; the lining being much thinner, the capacity of the mill is increased; the tcarge is carried higher thus reducing the inert zone; the life of a rubber lining is longer hahn that of porcelain and relining can be done in half a day. M.E.M.

Fine grinding machines. J. W. HINCHLEY. *Chem. Eng. Min. Rev.*, **19**, 143–44 (1926).—Size reduction takes place by 3 methods: crushing, shearing, and impact. Methods in which crushing predominates are more efficient than the others. In a ball mill all 3 methods are possible depending on the speed of rotation. The speed for grinding wet should be r. p. m. $=200\sqrt{D}$ where D is the diameter of the mill in inches. For dry grinding this should be 10% higher. Insufficient pulley power is frequently found, the mills sometimes taking 30% more energy than is necessary, while the cost of belt replacement is high. M.E.M.

Cost analysis of cement material handling. ANON. *Rock Products*, **30** [5], 98–99 (1927).—Results of a survey made at the Aetna Portland Cement Co., Bay City, Mich., on traveling cranes equipped with 2½ yd. clam-shell buckets. F.P.H.

Automatic draft regulator. ANON. *Emaillew. Ind.*, No. 26, 130(1926).—The Krupp draft regulator is described. It consists essentially of an iron frame in which a metal lid or damper is suspended on two pivots in such a manner that the damper readily swings inward under draft pressure, thus admitting air to the chimney flue. Part of the weight of the damper is counterbalanced by an adjustable weight fixed to the lever at the top. (*Trans. Ceram. Soc.* [Eng.])

PATENT

Comminuting china clay. K. G. VARCOE AND H. P. HARVEY. Eng. Pat., 253,694, May 18, 1925. Relates to rasping and absorbing apparatus. The clay is fed to a revolving disk which carries on the face against which the clay gravitates, knives having curved or double-inclined cutting edges which coöperate with slots or series of holes in the disk. The knives are adjustable and removable. The clay is disintegrated by the knives and passes through the slots into a delivering chute. Both portable and stationary machines are described. (*Trans. Ceram. Soc.* [Eng.])

Kilns, Furnaces, Fuels, and Combustion

Kiln construction. An efficient round, downdraft kiln for firing refractories. J. B. LYON. *Jour. Amer. Ceram. Soc.*, **10** [3], 185–204(1927).—Seventeen periodic kilns were studied for construction and design details, operation, and results. Eleven were round and six were rectangular. Alterations were made in grate area proportions, floor openings, flue design, and dimensions; the firing conditions and quality of ware obtained with each were recorded. The data obtained show effect on heat distribution and on time and fuel expenditures. Detail designs of flues are shown and the data are in tables and graphs. Detail specification and bill of materials are given for the 30-foot round kiln which was found to give best results in ware and costs.

An electric tunnel kiln. A. S. W. ODELBERG. *Jour. Amer. Ceram. Soc.*, 10 [3], 210–19(1927).—A diagrammatic description of kilns and resistors is given for electric tunnel kilns suitable for small ware. Experience, cost data, and results of biscuit, glost, and decorating are recited. Data are given showing that with high power cost the net cost per cup or plate is less in an electric tunnel kiln than in periodic kilns.

City gas successfully firing brick. ANON. *Brick Clay Rec.*, **70** [4], 292–93(1927). —A description of the plant of the Lake View Brick Company where city gas is used for firing brick. The firing time has been cut from 70 hours with coal and wood to between 30 and 35 hours with gas. Kilns are of the updraft, scove type with no permanent side walls or arches. Several advantages claimed for gas are enumerated. F.P.H.

Carbon losses. W. GUMZ. *Feuerungstechnik*, **14** [8], 85(1927).—Recent extended use of low grade fuels, forced draft and pulverized coal renders usual gas analysis untrustworthy unless allowance is made for considerable carbon losses in the form of coke particles and soot. Methods of determining and preventing losses discussed. F.A.W.

Determination of heat losses through furnace walls. K. HUFFELMANN. *Feuerungstechnik*, **15** [10], 109(1927).—Description of furnace with which tests were made. Formula for determining outer wall temperature developed and checked against published data. F.A.W.

Mechanical stokers for gas producers. R. MÖLLER. *Feuerungstechnik*, **15** [10], 113(1927).—Describes and illustrates various automatic stokers for gas producers. F.A.W.

New continuous decorating kiln placed in operation. ANON. *Fuels and Fur.*, **5** [2], 181–82(1927).—A description of the construction and operation of a new decorating kiln, 147 feet long and capable of producing 4000 dozens of ware per day, which is provided with automatic combustion control and has many new mechanical features. A.E.R.W.

Refinements in control of tunnel kiln result in greatly improved efficiency. ANON. *Fuels and Fur.*, **5** [2], 187–92(1927).—A description of the construction and operation of a tunnel kiln used to fire sillimanite cores for spark plugs, illustrated with diagrams and photographs. Special means for regulating the tunnel atmosphere, pyrometer protection tubes resistant to gases and thermal shock, and rigid at high temperatures, close temperature control in the neighborhood of 2700°F, and the automatic control of all the drafts in the kiln result in 96% of the ware passing rigid requirements. A.E.R.W.

Electric furnace for firing porcelain and other ceramic products. A. PAOLONI. *Corr. d. Ceramisti*, **7**, 63(1926).—The thermal efficiency of the principal types of kilns fired with fuels, and their chief characteristics are discussed, and the possibility of substituting electrical energy for fuels is reviewed. The conditions which an electric furnace must fulfill and recent progress in the application of electric furnaces in ceramics are dealt with. An electric furnace firing porcelain is described, which has proved suitable for firing insulators to a temperature of 1400–1450°. A description is also given of a short electric tunnel furnace, about 8 m. long, which is used to fire daily 600 fire brick measuring 22 x 11 x 6 cm to a temperature of 1350°. (*Trans. Ceram. Soc.* [Eng.])

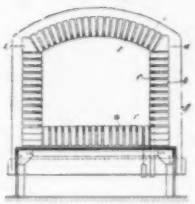
Construction and operation of tunnel kilns. W. POHL. *Tonind. Ztg.*, **50** (50th Anniv. No.), pp. 32–33(1927).—50 years ago Bock obtained the first German patent for a tunnel kiln and since then their use has increased gradually until now they are used in many medium as well as large size plants. In the 70s this kiln was used for brick, roofing tile, paving brick, etc. The Bock kilns were, however, faulty in construction and with few exceptions they were taken down after using them a short period of time. The only Bock kiln which is still in operation is at Zwickau and is used to fire 20,000 brick per day. The kiln is 60 m long, 1.60 m wide and has a height of 1.25 m inside over the bottom of the car. Each car holds about 500 brick and 30–40 minutes is consumed in pushing a car into the kiln. Many changes have been made in this kiln since it was erected by the present owners. In the mean time a tunnel kiln was developed in France by Faugeron which was used extensively in France for whiteware and in Germany in the 90s. These kilns were of faulty construction and their use was also discontinued after a short period. The tunnel kiln, therefore ceased to be used again until about 1905 when Faist studied the French tunnel kiln construction, modified it and introduced it into the fine ceramic industries. The kilns described above were of the direct fire type, that is, the ware was exposed to the kiln gases or was set in saggers on the cars. Shortly before the war a muffle tunnel kiln was introduced from England. The flame passes through the muffle canals and the gases do not come in contact with the ware. The use of such a kiln is limited since in firing certain types of ware it is desirable to fire reducing during a certain portion of the firing in order to render certain

impurities less harmful. The forerunners of the continuous muffle kilns were the Decor-muffles which have been used since 1910 for decorating porcelain and whiteware. The ware which has been dried is set in saggers and passed through a continuous muffle kiln on porcelain balls. The following data give the capacity and sizes of some tunnel kilns now being used in Germany: (1) *Brick.* 8,000 to 30,000 per day in a kiln 70 to 120 m long. The capacity and lengths of these kilns depends largely upon the sensitiveness of the clay to heating and cooling, (2) *Roofing tile.* Tunnel kilns are used for roofing tile but the capacities are not known, (3) *Refractories.* 20 to 100 tons per day with a kiln 50 to 110 m long, (4) *High tension insulators.* 400 to 500 cu.m. per week or 65 to 80 tons per week with kilns 70 to 90 m long, (5) *Low tension insulators.* 400 to 500 cu.m. per week or 70 to 90 tons with kilns 65–70 m long, (6) *Porcelain.* 450 to 500 cu.m. per week with a kiln about 70 m long, (7) *Sanitary whiteware.* 600 cu.m. per week at cones 6–10 with kilns 80 to 90 m long, (9) *Whiteware wall tile.* 50,000 tile per day in the biscuit fire and 50,000 per day in the glost fire for 4 kilns 70 to 110 m long. There are about 80 to 90 tunnel kilns in Germany. In the U. S. about 120 have been constructed comparatively recently. H.G.S.

BOOK

On the choice of a producer gas firing system. L. LITINSKY. 29 pp. Halle (Salle). W. Knapp, 1926.—A general discussion presenting the advantages and disadvantages of various gas producer systems. The cardinal question of retorts or chambers is discussed at length as is the question of vertical, horizontal, or sloping chambers. Further topics taken up are: single or multiple layer operation, tamped or laid-up chambers, silica or chamotte (grog), regenerators and recuperators, individual or central generators, forced or natural draft, dry or water sealed traps, common or individual receivers, water- or mixed gas operation, and dry or wet quenching of the coke. E.J.V.

PATENTS



Electric resistance muffle furnace. WILHELM ROHN. U. S. 1,619,829. March 8, 1927. An electric muffle furnace comprising a closed chamber formed of heat resisting fire bricks, all of whose surfaces are flat, having their smaller sides facing inwardly and a flat heating band imbedded into the spaces between the bricks.

Art of firing ceramic and other products. C. T. HOLCROFT AND C. E. DOLL. U. S. 1,620,022, March 8, 1927. The art of firing articles in a kiln which consists in subjecting the articles to a firing heat free from products of combustion and concurrently therewith to a flow of air in direct contact with the articles or containers therefor.

Downdraft kilns. E. EVANS. Eng. Pat., 255,188, May 18, 1925.—The gases of combustion are drawn through the perforated floor and pass through hooded pipes covering holes in an intermediate floor to a space communicating with a central flue. Additional radial flues extend from the central flue to points near the periphery of the kiln. (*Trans. Ceram. Soc.* [Eng.])

Geology

Ceramic resources of the South. A. F. GREAVES-WALKER. *Ceramic Age*, 9 [2], 37–39 (1927).—Within the past decade the South has become the country's and, in many cases, the world's largest supply of the most important nonmetallic minerals, and is destined to become the world's largest producer. Even without accurate estimates,

it is plainly evident that, if a complete survey were made, the total reserves of these minerals would reach staggering figures and the possibilities of development be unlimited. Georgia has tremendous deposits of sedimentary kaolin and fullers' earth; North Carolina has feldspar, residual kaolin, and pyrophyllite; Kentucky, high grade fire clays; Tennessee, ball clay; Arkansas, bauxite; Oklahoma, gypsum; Florida, zircon; and South Carolina, granite. G-W. gives a brief account of the resources of 15 states in the South. A.E.R.W.

Clay and clay products in Georgia. S. W. McCallie. *Ceramic Age*, 9 [2], 40–41 (1927).—The clays of Georgia now attracting the most attention are the sedimentary kaolins of the Coastal Plain. The total production for last year was 168,369 tons valued at $1,092,632. M. gives the mode of occurrence, typical analysis, and main uses of these clays. The production statistics for the clay-products industries for 1925 are given. Georgia also has extensive alluvial clays and shales. Their occurrence and utilization is described. The State Geological Survey is engaged in making a study of the clays of the state. A.E.R.W.

Mineral development of Georgia. A. V. Henry. *Ceramic Age*, 9 [2], 42–43 (1927). —The state of Georgia now produces almost one-half of the white-firing clays mined in this country, although much of the clay territory has been neither prospected nor exploited. These clays have been classified as soft, semihard, hard, flint, and bauxitic. Clays of the first 2 classes have been used mainly in the ceramic white ware and filler trades, the others for refractories purposes. H. gives a brief account of the work completed and in progress at the Georgia School of Technology in training students and in coöperating with the ceramic industries, State Geological Survey, and the Central of Georgia Railway in making a survey of the clays of the state and in determining their adaptability to the manufacture of saggers and other ceramic wares. A.E.R.W.

North Carolina pyrophyllite deposits. Jasper L. Stuckey. *Ceramic Age*, 9 [2], 48–49 (1927).—Pyrophyllite, $H_2Al_2Si_4O_{12}$, is distributed widely in nature and is well known in academic circles but is seldom thought of as an important mineral of commerce. North Carolina has the only known commercial deposits of pyrophyllite in the United States. These are limited to an area about 25 miles long by 5 miles wide located in the Deep River region in the central part of Moore and the south-central part of Chatham counties, near the center of the state. The pyrophyllite bodies are usually oval or lenticular in shape and vary in width from 200 to 500 ft. and in length from 500 to 2000 ft. S. describes the character of the pyrophyllite bodies, and the method of mining, commercial production, and growing utility of pyrophyllite. It has proved a good substitute for talc and has a promising future as a ceramic material. A.E.R.W.

Ball clays of Butler County, Missouri. H. A. Buehler. *Ceramic Age*, 9 [2], 50–51 (1927).—Deposits of dark-colored, light-firing ball clays were discovered in Butler County in 1920 and have since been developed. They are thought to be of tertiary age and to have been deposited in estuaries along the old tertiary shore line. Two deposits, the Kirby Mine and the Aden Pit, are being worked at the present time. The former is estimated to contain 350,000 tons, of which 8,000 tons have been removed, the latter 450,000 tons, of which 4,000 tons have been mined. The clay from the Kirby mine is said to have low shrinkage, a long firing range, and high tensile strength, and is used for electric porcelains, high-tension insulators, art, floor, and wall tile, and dinner ware. The clay from the Aden pit is not so plastic but is finer grained, tough, rubbery, and very black in color. It is used in special refractories, in abrasive wheels, and in the manufacture of art, floor, wall, and decorative tile, electric porcelains, and sanitary ware. A.E.R.W.

Ceramic development in Texas. E. H. Brown. *Ceramic Age*, 9 [2], 51–52 (1927). —Fifty-five establishments in Texas in 1923 produced more than $5,500,000 worth of

clay products. B. presents charts comparing the value of production and the number of plants in Texas and in the U.S. for the years 1914–23. Texas held its own in pottery products and more than held its own in brick manufacture. A gradual concentration into fewer but larger plants and an increase in manufacturing efficiency is taking place. A materially greater advance is predicted for the next 10 years. A.E.R.W.

Find potash in 26 more wells in Texas and New Mexico. ANON. *Amer. Glass Rev.*, **46** [21], 16 (1927).—Analyses of cuttings from oil wells show that there are now about 70 wells in Texas and New Mexico that have furnished potash-bearing samples. Core drilling is to be begun soon by the Geological Survey to determine the extent of the field of potash-bearing beds. E.J.V.

Source and origin of limestone deposits. ARTHUR C. AVRIL. *Rock Products*, **30** [5], 56–57 (1927).—The classification of limestone according to formation and characteristics is described. F.P.H.

Bauxite from Nyasaland. ANON. *Bull. Imperial Inst.*, **24**, 731 (1926).—Important bauxite deposits were first observed in 1924, in the Luchenya Plateau, but subsequent investigation shows the occurrence to a smaller extent, in other parts of the Mlanje mountains. The government geologist estimates that if an average depth of 7 ft. of workable ore be assumed, the Luchenya deposit contains not less than 20 million tons of bauxite. Samples analyzed in the laboratories of the Imperial Institute indicate that the ore nearer the surface is superior to that from the lower portion of the deposit. O.P.R.O.

Lithium minerals. L. H. COLE AND V. L. EARDLEY-WILMOT. Investigations of Mineral Resources. Canada Dept. of Mines, Mines Branch, pp. 69–75 (1926).—Lithium-bearing minerals occur in the Hull District, Quebec, and in a deposit 100 miles north of Winnipeg, Manitoba in sufficient quantities to warrant further development and have been further noted in Nova Scotia, Ontario, and B. C. Probably the most extensive use of lithium minerals is in the glass industry, in which lepidolite is employed in the manufacture of opal and white glass, and to an increasing extent in the production of certain types of flint glasses. Since both fluorine and lithia are active fluxing agents, the high fluorine content of lepidolite is partly responsible for its value in glass-making. O.P.R.O.

Swabian clays. A. GUTBIER AND W. BRINTZINGER. *Tonind. Ztg.*, **49**, 1245 (1925).—Analytical and ceramic data are reported on several Swabian clays. (*Trans. Ceram. Soc.* [Eng.])

BOOK

Physico-chemical geology. R. H. RASTALL. London: E. Arnold & Co., 1927. Price 15s. H.H.S.

Chemistry and Physics

Aqueous solutions of sodium silicates. R. W. HARMAN. *Jour. Phys. Chem.*, **31** [3], 355–73 (1927).—Vapor pressure measurements were made, varying the ratio, $Na_2O:SiO_2$ from 1:1 to 1:2, and over a concentration range from .1 to 2.5 *Nw*. Freezing point measurements were made for $Na_2O:SiO_2$ ratios, 1:1, 1:2, 1:3, and 1:4, and over a concentration range .01 to 2.0 *Nw*. Ratios 2:1 and 1:1 and to a less degree 1:2 show high degree of osmotic activity, more especially in dilute solution. The ratio, 1:1 is the salt Na_2SiO_3 undergoing both hydrolytic and ionic dissociation to Na^+, OH^- and SiO_3-ions and crystalloidal H_2SiO_3. Na_2SiO_3 is practically completely dissociated in dilute solution but only 27.8% hydrolytically. Ratio 1:2 is the definite salt $NaHSiO_3$, which like Na_2SiO_3, gives rise to Na^+, OH^- and SiO_3-ions and H_2SiO_3 but with .6% dissociation at .005 molal concentration and .05% hydrolytic dissociation. The results from ratios 1:3 and 1:4 are not in agreement with the view held that these ratios are de-

finite compounds but rather indicate their existence in form of complex aggregates in concentrated solution and of ionic micelle of the composition; $(m\ SiO_2 \cdot n\ SiO_2 aq)^m$, where $m+n/m$ = ratio. L. A.P.

Some technical uses of X-rays. ANCEL ST. JOHN. *Ind. Eng. Chem.*, **19** [3], 339–42 (1927).—A picture of the nature of X-rays, the relation of X-rays to atomic structure, and the application of X-rays to technical problems. Mention is made of various successful applications of X-rays to commercial problems. It is shown that in many cases the X-ray can be used to show the distribution of abnormal material such as sand in steel cavities, metal inclusions in electrical insulators, etc. The X-ray is also used to detect changes due to thermal, mechanical, or chemical treatment of material which has the same chemical composition and the same appearance under the microscope after such treatment as it did before. R.J.P.

The preparation and optical properties of calcium hydroxide. F. W. ASHTON AND RAYMOND WILSON. *Amer. Jour. Sci.*, 5th series, **13** [75], 209–18 (1927).—Calcium hydroxide is one of the products of hydrolysis of Portland cement. The properties of crystallized calcium hydroxide are as follows: (1) Calcium hydroxide crystallizes in the hexagonal system usually as plates or short hexagonal prisms, with perfect cleavage parallel to the face (.0001). (2) The refractive indices are $\omega = 1.574 \pm .003$, $\epsilon = 1.545 \pm .003$ for sodium light. Birefraction is .029, specific gravity $2.23 \pm .005$. Interference figure is uniaxial negative. Lattice constants $a_0 = 3.579$ Å, $c_0 = 5.028$ Å. The unit cell contains one molecule. (3) The crystals are nonhydrated, fairly stable in air, only slowly dissolved by water. When exposed to moist air or to water containing carbon dioxide they tarnish in a short time, becoming covered with a crust of carbonate. F.P.H.

The preparation of optically clear selenium for use in index media. L. T. BROWNMILLER. *Jour. Min. Soc. Amer.*, **12** [2], 43–48 (1927).—In the preparation of selenium-sulphur mixtures for use as index media, one is encountered with the difficulty of obtaining selenium which is optically clear when melted into thin films. Minute particles of another phase are commonly present which interfere with the determinations. These have been identified as selenium dioxide, and a method is described for the removal of this material by distillation in an atmosphere of carbon dioxide. F.P.H.

The CaO-Fe_2O_3 and MgO-Fe_2O_3 systems. ANON. *Rock Products*, **30** [4], 80 (1927).—An abstract of an article by Eugen Grunewald of Mainz, Germany. F.P.H.

The testing of the stability of blast furnace slags by means of ultra-violet light and the cause of the disintegration of these slags. A. GUTTMAN. *Stahl u. Eisen*, **46** [42], 1423–28 (1926).—Ultra-violet light can be used to distinguish between stable and unstable slags. Stable slags when examined under the microscope in ultra-violet show a distinct violet fluorescence. The disintegration of blast furnace slags is similar to the "dusting" of Portland cement clinker and is caused by the change in form of the dicalcium silicate. This change produces a volume change of about 10% and shatters the slag. The γ form of dicalcium silicate can be distinguished from the α and β form by means of the ultra-violet light. F.P.H.

On the measuring of low temperatures. I. ESTERMANN. *Die Messtechnik*, **2** [7], 89–93 (1926).—Descriptions of thermometers adapted for the measurement of low temperatures with information as to their range of application are given. These include: (1) liquid and gas-thermometers; (2) vapor pressure (tension) thermometers; (3) electrical thermometers (resistance thermometers and thermomelements). At the end are given some fixed points adapted to the standardization of the thermometers for below freezing. E.J.V.

A new apparatus for the determination of thermal expansion of solid bodies produced by the optical institution C. P. Goerz. HOFFMAN. *Die Glas-Industrie*, **34** [4], 84–85 (1926).—A description of the construction and principle of operation of a new apparatus produced by C. P. Goerz. E.J.V.

Quantitative spectroscopic analysis. F. TWYMAN. *Chem. and Ind.*, **46,** 165–66 (1927).—An element can readily be distinguished in presence of any other element, without the necessity of separation, by means of the spectroscope. The process is made quantitative by observing the intensity of the spectrum lines. One can thus distinguish between 0.001, 0.01, 0.1, and 1% of any impurity. Examples were given, relating to Ca in Mg, Al in brass, Ni and Cr in steel, Bi in Cu. H.H.S.

Quantitative spectrographic analysis. J. R. GREEN. *Chem. and Ind.*, **46,** 167 (1927).—When the content of a "foreign" element is small, say 1%, few of its spectrum lines appear. By carefully comparing spectra of similar substances of known composition with that of the unknown taken on the same plate and under the same conditions the per cent of the foreign element can be very closely determined. H.H.S.

Use of microscope in analysis. B. D. W. LUFF. *Chem. and Ind.*, **46,** 190–91 (1927). —In qualitative analysis by the microscope, the reagents used are such as give precipitates of a definite crystalline structure, and the substances are identified by their characteristic crystals. The slide is generally of glass, but in certain cases bakelite or celluloid are used. If it is desired to know whether gas is evolved, the solid under test is covered with a drop of gelatin, and the bubbles of gas imprisoned in the gelatin are easily visible. Filtration is effected by pressing a narrow glass tube on to a filter paper resting on the slide, and drawing the liquid into the tube through the paper by gentle suction. Microchemical analysis is of special use when only small quantities of material are available, and it effects economy in reagents and in space occupied. The petrological microscope for classifying crystals is explained. H.H.S.

Stoneware centrifugal pump. ANON. *Indus. Chemist*, **3,** 62 (1927).—Chemists and chemical engineers are ever on the watch for a pump that will deal with any type of liquids, combining in one, anticorrosive properties, high efficiency, low-running costs, simplicity and strength, and small space. The Doulton Stoneware Centrifugal Pump goes far toward the solution. The Doulton pump, every detail of which, except the outer iron casting, is made of special acid proof stoneware, the eight propellers, which are highly glazed, are constructed so that the thickness increases as the disk is approached and mold into it. The result is one of great strength and solidity, together with perfect balance of the impellers. With regard to leakage of liquid past the disk, the reverse side possesses a series of flat impellers, $\frac{1}{4}$ in. wide and $\frac{1}{8}$ in. high, so that any liquid issuing is swept back again. The disk rotates at the rate of 800 r.p.m. to 1800 r.p.m., according to height pumped. All the stoneware working parts are accurately machined and ground while the outside of the pump is extremely tough, and no difficulty is experienced in tightening up joints and flanges. O.P.R.O.

Air moisture in drying operations. A. J. V. UNDERWOOD. *Chem. Trade Jour.*, **79,** 363 (1926).—A chart is given, from which the amount of moisture in air at a given temperature and of a given degree of saturation, as well as the dew-point, can be readily determined. (*Trans. Ceram. Soc.* [Eng.])

Technical clay analyses. H. BACKE. *Keram. Rund.*, **34,** 20 (1926).—The sources of error in rational analyses (Berdel method) are avoided in the following manner: The total silica is removed by evaporating with H_2SO_4 and HF, the residue dissolved in hot water and the Al_2O_3 precipitated. The filtrate is dried and ignited, and its potassium content determined. The feldspar is calculated from the K_2O content; after deducting the alumina of the feldspar from the total Al_2O_3, the remainder gives the Al_2O_3 content of the clay substance. The difference from 100 gives the quartz. The time taken for an analysis is 1.5 days as compared with 2 or 3 days by the Berdel method.
(*Trans. Ceram. Soc.* [Eng.])

Note on the colloid-chemistry of clays and kaolins. K. NISHIKAWA. *Koll. Zeit.*, **38,** 328 (1926).—A viscosimetric study was made of the hydration process on mixing clays with water. A number of German and Japanese clays were investigated.
(*Trans. Ceram. Soc.* [Eng.])

Silicate analysis. ANON. *Chem. and Ind.*, **46**, 191–92(1927).—Joint meeting of Society of Chemical Industry (Yorkshire section) and Society of Glass Technology, Feb. 16, 1927. H.H.S.

New method for complete analysis of fluorspar. E. BAILLEUX. *Bull. soc. chim. Belg.*, **35**, 305–10(1926).—Detailed directions are given for the determination of ignition loss, $CaCO_3$, $Fe_2O_3+Al_2O_3$, SiO_2, CaF_2, $CaSO_4$, and $BaSO_4$. $CaSO_4$ is extracted from the residue of CaF_2 by a solution containing 500cc 65% AcOH, NH_4OH to neutralize the former, and 80 g citric acid, the mixture diluted to 1 liter, the Ca = CaSO being determined in the filtrate. The CaF_2 is determined as the residue from this extraction, but if Ba is present the CaF_2 is decomposed with H_2SO_4 extracted with dilute HCl, and the residual $BaSO_4$ determined. (*C. A.*)

Determination of free alumina in bauxite. ERNEST MARTIN. *Chimie et industrie*, **Special No.**, 200–201 (Sept. 1926).—The method is based on the following facts: $BaCO_3$ is soluble without decomposition in NaCl which is at or near its melting point; on adding bauxite, the free Al_2O_3 displaces the CO_2 to give Ba aluminate; natural Al silicates (kaolin, clays) under these conditions do not decompose $BaCO_3$ to give Ba aluminates, provided the temperature is not much higher than the melting point of NaCl; all constituents of bauxite, except free Al_2O_3, give H_2O-insoluble products when calcined with $BaCO_3$; the presence of free SiO_2 does not decrease the total amount of Al_2O_3 extracted, showing that no Al silicate is formed but as it combines with $BaCO_3$ before Al_2O_3 extraction of the latter takes longer. The following technic is recommended: heat a mixture of 0.5 g bauxite (dried at 110°), 3 g $BaCO_3$ (free from alkali) and 10 g NaCl (free from sulphates) in a Pt or Fe crucible over a Méker burner to about 880° and keep in a semifused state for 30 min., take up in 250cc boiling H_2O, filter on a pleated filter, ignite below redness, mix with 8 g NaCl, heat again for 30 min., and repeat the treatment until practically no more Al_2O_3 is extracted (at least 5 extractions). Because of the large volume of liquid (about 500cc in each case) do not combine, but precipitate in each separately, first Ba with H_2SO_4, and then Al_2O_3 with NH_4OH, combine all the Al_2O_3 precipitates on 1 or 2 filter papers, ignite all the precipitates in the same crucible, and weigh. Calcined Al_2O_3 and baked bauxites are attacked in the same way by $BaCO_3$ as hydrated Al_2O_3 or hydrated bauxites, showing that H_2O of constitution has no effect. The method is inapplicable to rocks containing alkalis, which are never present in bauxites. The determination affords a chemical method of differentiating between bauxites and natural Al silicates. (*C. A.*)

The hydrolysis of zirconium chromate. PANCHAPAKISA KRISHNAMURTI AND BIMAN BIHARI DEY. *Z. anorg. allgem. Chem.*, **158**, 94–98(1926).—The precipitation of concentrated solutions of Zr salts by $K_2Cr_2O_7$ gives $Zr(OH)_4 \cdot 2Zr(OH)_2CrO_4$. When the Zr solution is dilute and the dichromate in large excess, with or without addition of NaOAc, the formula of the precipitate is $Zr(OH)_4 \cdot Zr(OH)_2CrO_4$. When dilute hot Zr solutions and slight excess of dichromate are used, and the precipitate is washed, the formula is approximately $2Zr(OH)_4 \cdot Zr(OH)_2CrO_4$, but Cr is lost on washing. (*C. A.*)

The system aluminum-calcium-silicon. G. DOAN. *Z. Metallkunde*, **18**, 350–55 (1926).—The object was to determine the possibility of using Ca-Si compounds for refining Al, and to investigate the ternary system Al-Ca-Si. Common Al, containing 0.48% Si and 0.35% Fe, "silumin," containing 13.17% Si and 0.6% Fe, and metallic Ca (98.5%) were the materials used, and the general method was to prepare a Ca-Al alloy and add this in the required quantity to the fused silumin. On adding Si to Al-Ca alloys, the following reaction occurs: $CaAl_2+2\,Si = CaSi_2+3\,Al$. D. finds that the compounds CaSi and Ca_2Si are decomposed in Al melts, forming $CaSi_2$; $2\,CaSi+3Al = CaAl_2+CaSi_2$ and $2Ca_2Si+9\,Al\ 3CaAl_2+CaSi_2$. This is confirmed by photomicrographs, no CaSi being formed. $CaSi_2$ forms a eutectic series with Al containing about

4.6% $CaSi_2$, and melting at about 637°. The solubility of $CaSi_2$ in liquid Al is increased considerably by additions of Ca or Si. An addition of Ca to the silumin eutectic lowers the melting point of the binary alloy to 578°. It takes up between 0.5 and 3.2% Ca in solid solution further additions leading to increase in $CaSi_2$. Addition of Si does not produce a lowering of the eutectic, up to 1% being taken up by the binary eutectic to form a ternary eutectic with about the same melting point. With more Si, $CaSi_2$ is formed. Equilibrium diagrams and space models are shown. Al shows typical undercooling phenomena. $CaSi_2$ appears as the first to separate from the melt, then dendrites of Al, and then a small amount of the true eutectic. $CaAl_2$ has a much greater crystallization velocity than Al. A close examination of photomicrographs shows that the $CaAl_2$ needles have jagged edges, owing to the separation of Al dendrites. D. states that a ternary intermetallic compound of the type $Al_xCa_ySi_z$ is improbable. (*C. A.*)

Action of heat on the surface properties of kaolin. RENE DUBRISAY. *Compt. rend.*, **183**, 782–84 (1926).—Absorptive power for I and for methylene blue was reduced by heating, the amount of reduction increasing with the temperature to which the kaolin was heated. The heat developed on moistening with H_2O and with NNH_3 decreased on heating (in both cases the sample heated 2 hrs. at 250° gave a slightly higher heat than the untreated sample). On mixing 5 g. of sample with 10 cc. of H_2O or of lime water and allowing to stand for 5 days, the ratio of the volume of clear H_2O to the volume of kaolin H_2O mixture increased with temperature of heating, showing decrease in the power of imbibition; while the opposite was observed with NNH_3. (*C. A.*)

Theory of the heat of fusion. N. v. RASCHEVSKY. *Z. Physik*, **40**, 214–19 (1926).—On the assumption that the liquid condition is characterized by the atoms being so far apart that tne modulus of elasticity becomes zero, the heat of fusion of several metals was calculated and compared with the experimental value. The agreement is fairly good. (*C. A.*)

New method for the determination of true specific heats at high temperatures. H. KLINKHARDT. *Z. Elektrochem.*, **32**, 534–35 (1926).—K. determined the true specific heat of Ni up to 450° by heating a Ni cylinder inside a high-vacuum container (placed in an electric furnace) by means of the electronic energy supplied by a Th-covered W filament. The method is also applicable to insulators and substances having a high vapor pressure. These are enclosed in a metal container. The heat of transformation of NH_4Cl at 184.5° was found to be 970 cal./g. Discussion by Drucker and Eucken. (*C. A.*)

Analysis of silicates. A. LASSIEUR. *Bull. Soc. chim.*, **39** [4], 1759–66 (1926).—The silicate is treated with hydrochloric acid either before or after fusion with sodium carbonate, evaporated to dryness, and heated at 105–110° till no more fumes of acid are evolved. By treating cold with 5 cc of concentrated hydrochloric acid and, after 10 min., adding 100 cc of boiling water the silica can be filtered. Contrary to Treadwell's statement silica is precipitated completely and in a pure state under these conditions. The hot solution is now just neutralized with ammonia, when the hydroxides of iron, aluminium, and titanium are precipitated, their separation being effected by calcining and treating with potassium bisulphate. The precipitate is obtained free from alkalis, alkaline-earths, and magnesium, but excess of ammonia must be avoided as it precipitates magnesium and also dissolves appreciably the aluminium hydroxide. Both these effects can be avoided by adding ammonium salts, but some 10 g.-mol. are required per g.-mol. of aluminium. Calcium is precipitated by adding saturated ammonium oxalate solution to the hot ammoniacal solution; the presence of the great excess of alkali salts from the fusion is not deleterious, but magnesium is carried down and can be separated by reprecipitating the calcium with ammonium oxalate

in solution of *p*H 4 or 5. In the final precipitation of magnesium as the ammonium phosphate, excess ammonia as usually stated is unnecessary, a *p*H slightly over 7 being sufficient. (*Brit.C.A.*)

BOOK

Introduction to Exact Technical Temperature Measurements. O. KNOLAUCH AND K. HENCHY. Reviewed by *Min. and Met.*, **8** [242], 97 (1927). F.P.H.

Applied X-rays. G. L. CLARK. Pp. 255. New York: McGraw-Hill Co., 1927. Price $5.00.—X-rays as a new tool for industry. Qualitative and quantitative analysis by X-rays; X-rays as a means to the study of colloidal and amorphous structure. Twenty-two chapters of practical work. H.H.S.

PATENTS

Zirconium compound and method of making same. C. J. KINZIE. U. S. 1,618,286. Feb. 22, 1927. In treating a zirconium ore to obtain an acid soluble zirconium compound, the steps which consist in fusing the ore with partial expulsion of silica in the resultant product, and mixing and heating the product with sulphuric acid at a temperature between 350° and 450°C.

Zirconium compound and method of making same. C. J. KINZIE. U. S. 1,618,287, Feb. 22, 1927. The method of making basic potassium zirconium sulphate which comprises adding an alkali to a solution of normal zirconium sulphate, treating the charge with potassium sulphate, and separating the precipitate formed as basic potassium zirconium sulphate.

Zirconium oxide silica composite and method of making same. C. J. KINZIE U. S. 1,618,288, Feb. 22, 1927. The method of preparing a zirconium oxide silica composite which comprises heating zirconium-containing material with a less quantity of an alkali to substantial decomposition of the material, treating the residue with acid to obtain both zirconium and silicon compound in solution, then heating the charge in the presence of sufficient alkali metal compound to precipitate the zirconium compound as a double zirconium salt of the alkali metal, and finally drying the resulting product.

Process for the recovery of titanic acid iron, and magnesia from titaniferous ores. F. E. BACHMAN. U. S. 1,618,795, Feb. 22, 1927. That step in the process of treating a solid titanic hydrate, which consists in heating the material with acid at a temperature higher than its boiling point.

Process for the treatment of leucite and other sodium and potassium silicates with lime for the purpose of extracting potassium or sodium and aluminum value. FÉLIX JOURDAN. U. S. 1,620,212, March 8, 1927. The process of producing potash and alumina from leucite treated with lime at a high temperature, until the mixture is caused to melt, which process consists in so casting the molten product that it will form big lumps, and then cooling these down in such a way as to cause them to disintegrate into a powdery mass.

General

Statistical methods in ceramic research. A. E. R. WESTMAN. *Jour. Amer. Ceram. Soc.*, **10** [3], 133–47 (1927).—It is the fundamental object of ceramic research to build up a science of ceramics which will enable us to produce, in the most efficient manner and from a certain group of raw materials, finished products which will have prescribed sets of physical properties. In attempting to reach this objective, it is of importance that we develop new methods of research which are particularly fitted to solve our fundamental problems, and apply, as effectively as possible, the research methods which are now available. These research methods can be divided, on a working basis, into two

classes, (1) *exact methods* in which the relationship existing between any two variables is determined by experiments in which the effects of all the other variables are rendered negligible by careful control of the experimental conditions, (2) *statistical methods*, which are used when it is impossible or impracticable to obtain such close control of the experimental conditions or when sampling errors are important and it is possible to repeat the experiments many times. It is tne purpose of this paper to draw attention to the fact that we, as ceramists, have almost entirely neglected this second group of methods; to give a brief description, with examples, of some of the modern statistical methods, especially those used by the biometrists; and to point out a few of the situations in which these methods could be used to advantage in ceramic research, especially in investigations of refractory materials.

Presidential address. R. L. CLARE. *Bull. Amer. Ceram. Soc.*, **6** [3], 67–69 (1927). —The completion of a most successful and satisfactory year is reported. Operation within the budget allowance, growth in membership by 237 personal and 34 corporation members, publication of the *Refractories Bibliography*, record publication of original papers and abstracts of the world's literature, and records in work produced by the various committees are the chief achievements recorded. The subject of ceramic education and the formation of a research body separate from the SOCIETY but made up of SOCIETY members are discussed. E.J.V.

American Ceramic Society's annual convention. ANON. *Glass Industry*, **8** [3], 49–57 (1927).—A report of the meeting held at Detroit, officers elected, and abstracts of the following papers presented at the Glass Division meetings: "The Frosting of Glass by Mixtures Containing Hydrofluoric Acid and Alkaline Fluorides," by C. D. Spencer; "The Loss of Silica during Glass Melting," by S. R. Scholes; "Properties and Service of Glass Melting Pots," by Donald Ross; "The Relation between Chemical Composition and the Thermal Expansion of Glass," by S. English and W. E. S. Turner; "New Type of Tunnel Tank Replaces Day Tank," by W. S. Williams; "Tentative Standard Method of Glass Analysis;" "Some Aspects of American Glass Tank Practice," by Fred S. Thompson; and "A Method for Measuring the Softening Temperature of Glass," by J. T. Littleton, Jr. E.J.V.

The Ceramic Society. ANON. *Pottery Gaz.*, **52** [597], 441–45 (1927).—J. Konarzewski and A. E. J. Vickers presented a paper on "The Discoloration of Clays during Firing." Previous researches by Seger and Mellor are summarized. Work carried out by A. Hopwood and W. Jackson to discover why white- or yellow-firing clays sometimes became red on firing confirmed Seger and lent support to the theory that sulphur compounds were the cause of the red coloration produced in clays. Moore and Mellor gave support to the hypothesis that the coloration of clay wares was primarily a function of the atmosphere in which the piece was immersed. The present investigation was to examine more fully and under more strict experimental conditions the influence of water vapor and sulphur dioxide upon the color produced in the piece during the process of firing. An electric resistance tube through which gases could be conducted was used. The following conclusions were arrived at: (1) that the presence of water vapor during the dehydration period and the oxidation period of firing, and the presence of sulphur dioxide during the whole time of firing, produced a reddish coloration of white- and yellow-firing clays; (2) the presence of water vapor during the last stage of firing produced a lighter color than that obtained when the clay was fired under normal conditions; (3) the influence of these gases was especially strong when they acted upon the clay within the range of temperatures between 500° and 600°C; (4) the discoloration could be removed more or less by prolonged firing in an oxidizing atmosphere. The adsorption of sulphur dioxide is discussed. A general discussion of the results is added. E.J.V.

The Society of Glass Technology. ANON. *Pottery Gaz.*, **52**[597], 447–55(1927); *Nat. Glass Budget*, **42**, [44], 13(1927). E.J.V.

Effect of direct heating surface on efficiency. J. GOULD COUTANT. *Combustion*, **46** [2], 99–100(1927).—Data and calculations as evidence that direct heating surface in contact with the radiant heat of fire results in lower boiler efficiencies. Greater efficiency with use of refractories in modern boiler furnaces. Boiler furnaces should be so designed as to obtain highest initial temperature. Analyzes the effects of additional direct heating surface and by means of test figures and charts reaches conclusions different from those usually expressed. L.A.P.

The theory of drying. STEGER. *Tonind. Ztg.*, **50**, 50th Anniv. No., 28(1927). —The wetting and drying of clays take place in accordance to certain laws which are only partly understood at present. Although it is possible to drive off considerable water from clays at temperatures below 100°C, it is necessary to heat the clays over 100°C to drive off the last traces of water. By studying the loss in weight and drying shrinkage of clays by drying them at a constant low temperature, two distinct periods in the drying are noticed. (1) The loss in weight is proportional to the time of drying. The rate of evaporation of the water from the clay obeys a simple law, namely, that it is proportional to the difference between the saturated vapor pressure at the temperature of the clay and the vapor pressure of the dry air. The drying shrinkage is approximately proportional to the loss of water. (2) The loss in weight of water continues and this approaches a point where no more is removed from the clay by holding it at constant temperature and the air at constant humidity although the clay still retains some water The vapor pressure of the clay no longer is equal to the saturated vapor pressure of water at the temperature of the clay but is lower. Consequently the rate of evaporation no longer follows the above simple law. The drying shrinkage has reached its maximum value at the beginning of the second drying period and the clay no longer shrinks during the second drying period or only slightly at most. In order to explain this phenomena we may consider the clay as consisting of extremely fine clay particles which may in themselves be porous. On the surface the particles are covered with a substance which is capable of becoming swollen with water such as hydrates of Si, Al, and Fe. In addition to these clay particles the clay also contains sand and feldspar. Upon wetting such fine particles as sand, the particles first become coated with a film of water. Where a number of particles are in contact with each other the films are communicated with each other and have the effect of pressing the grains together. The smaller the particles the greater will be the surface tension holding these together. If more water is added the films become thicker and finally no longer have the power of holding the particles together. Theoretically there is a certain water content at which the particles are held together with the greatest force. If we consider wetting clay particles the pores first become filled with water, and the addition of more water causes a film to be formed around the grains. The water used up to this point may be considered capillary water. If we add more water the pores between the particles become filled and this is called pore water. Up to this point the clay still has a rigid nonplastic state. The difference between the water at normal consistency and the pore water plus capillary water is known as water of plasticity. It is that water which comes between the particles and causes the hydrates to swell. An increase in volume is thereby produced which later during drying causes shrinkage. This water of plasticity gives to a clay its workability. During drying the same action described during wetting takes place in the opposite direction. In the first place shrinkage takes place which causes the particles to come closer together while the water of plasticity is being driven off. The shrinkage is greater when more water is employed. Next the water from the spaces between the particles is driven off producing a strong body. Finally the capillary water and the water in the

pores of the clay particles are driven off and this requires a temperature above the boiling temperature of water. H.G.S.

Common brick in fighting trim. ANON. *Brick Clay Rec.*, **70** [5], 368–75 (1927).—A report of the 9th annual meeting of the Common Brick Manufacturers Association is given. F.P.H.

Clay machinery exhibits break record. ANON. *Brick Clay Rec.*, **70** [5] 376–77 (1927).—A description of clay machinery exhibited at the 9th annual meeting of the Common Brick Manufacturers Association is given. F.P.H.

American Ceramic Society meeting a record breaker. ANON. *Brick Clay Rec.*, **70** [5], 388–95 (1927).—The following papers presented before the Refractories, Terra Cotta, and Heavy Clay Products Divisions of the AMERICAN CERAMIC SOCIETY at the Feb. 1927 Annual Meeting are abstracted: (1) "A Study of the Refractory Properties of Silica Cement," by S. S. Cole; (2) "Producer Gas for Firing Fire Brick in a Tunnel Kiln," by Howard S. Orth; (3) "Some Physical Properties of Artificial Aluminous Abrasives," by A. Ernest MacGee; (4) "The Effect of Steam on the Transverse Strength of Fireclay Brick," by C. W. Parmelee and A. E. R. Westman; (5) "The Use of Superrefractories as Checker Brick in Gas Manufacture," by H. J. Knollman; (6) "Firing Terra Cotta in an Open Gas Fired Kiln," by W. Owens; (7) "Notes on Physical Properties of Terra Cotta," by Harry Spurrier; (8) "Drying Grinding Clay to 80-Mesh," by D. F. Albery; (9) "Some Physical Properties of Chemical Stoneware," by A. E. MacGee; (10) "Soluble Salts and Their Application to Terra Cotta," by Arnold H. Hottinger; (11) "Changes in Viscosity of Glaze Suspensions and Clay Slips on Aging and by Treatment with Electrolytes," by J. R. Bowman; (12) "Pink Discolorations on Terra Cotta," by Harry Spurrier; (13) "Drying Problems of Terra Cotta," by Frank A. Kirkpatrick, (14) "A Method of Determining Workability of Plastic Clays," by Samuel J. McDowell; (15) "Flashing and Other Unique Developments in Connection with a Modern Tunnel Kiln Face Brick Plant," by James T. Robson; (16) "Some Thermal Characteristics of Clays," by A. E. MacGee; (17) "Draft Comparison of Cement and Clay Gas Flues," by A. Lee Bennett; (18) "Flue Linings," by H. W. Clark and R. A. Hart; (19) "Mechanical Introduction of Barium to Clay Bodies," by Marion W. Blair; (20) "Types of Kilns," by Otto Kaufmann; (21) "New Ideas in Clay Working," by H. R. Straight; (22) "Power Consumption in Heavy Clay Products Plant," by Arthur Wills; (23) "Possibility of Salt Glazing Sewer Pipe in Tunnel Kiln," by W. D. Richardson; (24) "Items Requiring Considerations in Underground Clay Mining," by C. Forrest Tefft and Russel H. Hearring; (25) "Elimination of Lamination in Clay Bars," by A. F. Greaves-Walker. F.P.H.

Canadians adopt brick size. ANON. *Brick Clay Rec.*, **70** [5], 396–98 (1927).—Report of the 25th annual convention of the Canadian National Clay Products Association. Resolutions were passed adopting the following size of brick. Common and rough face $8 \times 3\frac{3}{4} \times 4\frac{1}{4}$ inches. Smooth face, $8 \times 3\frac{7}{8} \times 4\frac{1}{4}$ inches. F.P.H.

Ceramic mass production awes American Ceramic Society. ANON. *Ceram. Ind.*, **8** [3], 302–306 (1927).—A description of the plants visited by members of the AMERICAN CERAMIC SOCIETY who attended the Annual Meeting in Detroit. The following plants are described: (1) Ford River Rouge Plant, (2) Detroit-Michigan Stove Co., (3) Wolverine Porcelain Enameling Co., (4) Detroit Vapor Stove Co., (5) Enameling plant of the Chrysler Motor Co., (6) Champion Porcelain Co., (7) Mt. Clemens Pottery, (8) Pewabic Pottery, (9) Buckeye Clay Pot Co., (10) Libby Glass Plant. F.P.H.

Equipment and supply exhibit well patronized. ANON. *Ceram. Ind.*, **8** [3], 306 (1927).—A description of the equipment and supply exhibition presented at the AMERICAN CERAMIC SOCIETY Annual Meeting, 1927. F.P.H.

Glass analysis and microscopy hold glass men's interest. ANON. *Ceram. Ind.*, **8** [3], 315–23 (1927).—Abstracts of papers presented before the Glass Division of the AMERICAN CERAMIC SOCIETY at the Feb. 1927 Annual Meeting are given. The following papers are abstracted: (1) "Notes on Shape Construction," by F. H. Rhead; (2) "A Method for Measuring the Softening Temperature of Glasses," by J. T. Littleton Jr.; (3) "Some Aspects of American Glass Tank Practice," by Fred S. Thompson; (4) "New Type Tunnel Tank Replaces Day Tank," by W. S. Williams; (5) "Properties and Service of Glass Melting Pots," by Donald Ross; (6) "Large Clay Shapes for Window Glass Industry," by E. P. Arthur; (7) "Soda Lime Glass Analysis," by Dr. Lundell; (8) "Glass Factory in the Days of Nebuchadnezzar," by A. E. Marshall; (9) "The Relation between Chemical Composition and the Thermal Expansion of Glasses," by S. English and W. E. S. Turner; (10) "Frosting of Glass by Mixtures containing HF Acid and Alkaline Fluorides" by C. D. Spencer and L. Ott; (11) "Design and Service of Tank Blocks," by Donald Ross. F.P.H.

Controlling of enameling processes feature on enameler's program. ANON. *Ceram. Ind.*, **8** [3], 324–29 (1927).—Abstracts of papers presented before the Enamel Division of the AMERICAN CERAMIC SOCIETY at the Feb. 1927 Annual Meeting are given. The following papers are abstracted: (1) "Some Observations of the Aging of Enamels," by H. G. Wolfram; (2) "Effect of Mill Practice on Working Properties and Finish of Enamels," by J. E. Hansen; (3) Enamel Symposium on "Making and Firing of Sheet Steel Ground Coats;" (4) "Effects of Composition on the Properties of Ground Coat Enamels for Sheet Steel," by W. N. Harrison and H. G. Wolfram; (5) "The Electric Furnace in the Enamel Industry in Canada," by W. Mavor; (6) "Sheet Steel Cooking Ware White Enamels Economically Suitable for Use in China," by Chi-Fang Lai; (7) "Bringing Research up to Date," by R. D. Cooke; (8) "Equipment That Has Improved Our Enamel," by L. S. Weimer; (9) "Some Effects of Varying Soda and Boric Oxides in Ground Coat Enamels," by R. R. Fusselbaugh; (10) "Control Testing of Borax and Soda Ash Stocks," by W. V. Knowles; (11) "The Economic Trend of the Enameling Business," by H. R. Spencer; (12) "Effect of Various Electrolytes Added to Enamel Suspension with and without Clay," by H. L. Cook; (13) "The Necessity for Operating Standards and Procedure Control," by R. D. Landrum. F.P.H.

Vacuum treated slips and *p*H value discussed at white ware meeting. ANON. *Ceramic Ind.*, **8** [3], 329–35 (1927).—Abstracts of papers presented before the White Wares Division of the AMERICAN CERAMIC SOCIETY at the Feb. 1927 Annual Meeting are given. The following papers are abstracted: (1) "An Investigation of Some Ball and China Clays," by C. W. Parmelee and T. N. McVay; (2) "The Advantage of Good Design in Tableware," by F. A. Holmes; (3) "A Study of Factory Practice," by H. M. Kraner and E. H. Fritz; (4) "The Particle Size Distribution of Typical Feldspars and Flints," by E. Schramm and E. W. Scripture, Jr.; (5) "A Method of Determining Workability of Plastic Clays," by S. J. McDowell; (6) "The Economic Life of Molds," by W. L. Sample; (7) "Some Whiteware Bodies Developed at the Ohio State University," by A. S. Watts; (8) "Some Thermal Characteristics of Clay," by A. E. MacGee; (9) "An Electric Tunnel Kiln," by A. S. W. Odelberg; (10) "Hydrogen-ion Control in Ceramics," by W. A. Taylor; (11) "The Effect of Various Sodium Silicates and Other Electrolytes on Clay Slips," by S. J. McDowell; (12) "Statistical Methods in Ceramic Research—Some Possibilities," by A. E. R. Westman; (13) "The Behavior of Feldspar and Flint with Acids and Bases," by E. W. Scripture, Jr. F.P.H.

Art Division. ANON. *Ceram. Ind.*, **8** [3], 335–36 (1927).—The following papers presented before the Art Division of the AMERICAN CERAMIC SOCIETY, Feb. 1927 are abstracted: (1) The Greek Black Glaze," by Harold Nash and W. C. Peck; (2) "A Study of Color Theory and Its Application to Ceramic Art," by Theodore Lencher;

(3) "Low Fire Glazes Using Rutile," by M. M. French and C. M. Harder; (4) "Form and Color in American Indian Pottery North of Mexico," by R. M. Harrington. F.P.H.

Symposium on boiler-house refractories furnishes data. ANON. *Ceram. Ind.*, **8** [3], 336–42 (1927).—The following papers presented before the Refractories Division of the AMERICAN CERAMIC SOCIETY, Feb. 1927, are abstracted: (1) "Some Physical Properties of Chemical Stoneware," by A. E. MacGee; (2) Producer Gas for Firing Fire Brick in a Tunnel Kiln," by H. S. Orth; (3) "Some Physical Properties of Artificial Aluminous Abrasives," by A. E. MacGee; (4) "The Effect of Steam on the Transverse Strength of Fireclay Brick," by C. W. Parmelee and A. E. R. Westman; (5) "A Study of the Refractory Properties of Silica Cements," by S. S. Cole; (6) "A Brief Review of the Development of Ceramic Petrography," by A. B. Peck; (7) "Standardization and Plant Control as Applied to Body Making," by F. H. Riddle and Robert Twells; (8) "Draft Comparison of Cement and Clay Gas Flues," by A. L. Bennett; (9) "The Rôle of the Ceramic Petrographer," by A. B. Peck. F.P.H.

New Jersey clayworkers discuss many important problems at annual meeting. ANON. *Clay-Worker*, **87** [3], 210–12 (1927).—The following papers were presented: "The Physical Behavior of Gypsum Plaster," by F. M. Thorman; "Some Aspects of the European Ceramic Industries," by M. B. Catlin; "Ceramic Raw Materials in the West," by W. M. Myers; "Recent Whiteware Investigations at the Columbus Branch of the Bureau of Standards," by S. J. McDowell; "Prevention of Ceramic Defects in the Casting of Whitewares," by W. L. Shearer. F.P.H.

Fifty years of the Tonindustrie-Zeitung. ANON. *Clay-Worker*, **87** [3], 213 (1927). —A description of the Jubilee number of the *Tonindustrie-Zeitung*. F.P.H.

Costs and accounting as applied to the clay industry. RICHARD C. TURNER. *Clay-Worker*, **87** [3], 214–15 (1927).—The first of a series of articles on this subject. This article deals with costs applied to the clay industry. A cost flow sheet is given. F.P.H.

Annual convention of Hollow Tile Association. ANON. *Clay-Worker*, **87** [3], 216–17 (1927); *Brick Clay Rec.*, **70** [4], 264–66 (1927).—A report of the ninth annual convention of the Hollow Tile Association. F.P.H.

Uses and preparation of rock dust. W. M. WEIGEL. *Rock Products*, **30** [3], 65–68 (1927).—A discussion of the manufacture, equipment, cost, and marketing problems connected with the rock dust industry is given. The use in ceramics and glass making is described. F.P.H.

Detroit convention of the Sand-Lime-Brick Association. ANON. *Rock Products*, **30** [3], 76–78 (1927); **30** [4], 72–75 (1927).—A report of the 23rd annual convention of the Sand-Lime-Brick Association. F.P.H.

Details of research in fine grinding. ANON. *Rock Products*, **30** [4], 58 (1927). —An abstract of a paper presented to the British Institution of Chemical Engineers by Geoffrey Martin. A method of determining the surface exposed by particles by a study of solution of quartz in hydrofluoric acid for one hour at 25°C is described. To measure the power consumed in grinding an electrical method was used and this was checked by a mechanical method. The following conclusions are drawn: (1) In ordinary tube mill grinding the surface produced is proportional to the work done. (2) To increase the surface of sand by 1 sq. ft. requires 60.9 ft.-lbs. of work when 1-inch steel balls are used for grinding in an 18 x 18-inch mill. (3) With very prolonged grinding more work than this is required; the very fine particles evidently "cushion" the blow. (4) When grinding very finely the effect of dust in "cushioning" the blow becomes pronounced, and hence efficiency will be enhanced by removing it in an air stream. F.P.H.

Formulas for computing economics of labor-saving equipment. ANON. *Rock Products*, **30** [3], 80–81 (1927).—Committee of American Society of Mechanical Engineers,

Materials Handling Division, studies problem of evaluating labor saved by improved processes. F.P.H.

Lead poisoning. ANON. *Chem. and Ind.*, **46**, 174 (1927).—Replying to a question in Parliament, the Home Secretary said that during the years 1916–1926 there were 67 cases of lead poisoning in potteries using low-solubility glazes. Of these 67, 60 had previously worked in raw-lead glazes. H.H.S.

Porcelain-enameled steel reflectors. H. BUCKLEY AND C. J. W. GRIEVESON. Dept. of Scien. Indus. Research (England); *Illuminating Research Tech. Paper*, No. 3 (1926).—The artificial lighting of industrial processes demands a fitting which, in addition to providing adequate illumination for the work in hand, is reasonably permanent, moderate in cost, and easy to keep clean. Porcelain-enameled steel reflectors fulfil these requirements fairly well, and, in various shapes, have come into extensive use for industrial lighting. The type of reflector known as the Industrial Reflector Fitting (No. 1, British Engineering Standards Association) aims at combining the good qualities of the flat cone and of the deep bowl, avoiding the pronounced glare of the one and the patchy illumination of the other. O.P.R.O.

Occurrence and clinical manifestations of silicosis among hard ground workers in coal mines. NORMAN TATTERSALL. *J. Ind. Hyg.*, **8**, 466–80 (1926).—In large collieries there are usually one or two men per 100 who drill hard rock carrying 60% or more SiO_2. Some of these men have developed advanced silicosis and tuberculosis. There is some evidence to indicate that "dusting" in coal mines introduces a silicosis hazard. Men working on hard ground should be registered and subjected to periodical medical examination. Respirators and wet drilling are recommended. (*C. A.*)

Exposure to silica dust without the occurrence of silicosis. PATRICK HEFFERNAN. *J. Ind. Hyg.*, **8**, 481–90 (1926).—The silica dust arising in the manufacturing of Derbyshire ganister bricks contains about 84% SiO_2 and about 16% clay and earth with some organic matter. Apparently this admixture in some way interferes with the usual harmful influence of SiO_2, for the workers exposed to it do not develop silicosis or phthisis. (*C. A.*)

Experimental silicosis. E. H. KETTLE. *J. Ind. Hyg.*, **8**, 491–95 (1926).—K. favors the chemical explanation of silicosis, the SiO_2 being dissolved in the lungs forming colloidal silicic acid which is an active cell poison causing necrosis and inflammation, and finally the invasion of fibrous tissue. SiO_2 itself rather than the fibrous tissue or lack of lymphatic drainage seems to promote the growth of the tubercle bacillus. (*C. A.*)

Statistical characteristics of dust phthisis (pulmonary silicosis). E. L. COLLIS. *J. Ind. Hyg.*, **8**, 457–65 (1926). (*C. A.*)

New type of hose mask for protection against metallurgic dusts and fumes. L. G. DUNLAP. *J. Ind. Hyg.*, **8**, 513–14 (1926).—The mask consists of a hatlike, fiber helmet with suitable eyepieces, from which is suspended a length of ordinary muslin with armholes and tied about the waist; the helmet is held in place by ribbons tied under the chin; air is supplied by a hose and funnel diffuser suspended from the neck. Efficient protection is given against highly dangerous concentrations of flue dust, fumes, and gases. (*C. A.*)

BOOK REVIEWS

Peasant Art in Europe. H. T. BOSSERT. E. BENN, Ltd. London. Price £9 9*s*. *Pottery and Glass Rec.*, p. 71. This book, which is coördinate with the author's *Ornament* (published in 1924) is an epoch-marking work in the history of decorative art. It has two thousand examples, mostly in color, and the whole book is printed and finished in the same admirable style as its sister work. It, however, demonstrates the difference

between itself and the work on ornament as being parallel with modern art generally, and that of the Academics or followers of historical styles. The author is careful to explain at the outset, that his presentation of examples of *Folk Art* are to be taken seriously as examples of true art, but not, as some would claim—to the exclusion of other types of sophisticated, or instructed art—the art of the schools, guilds, craft-shops, and even trade workshops.

These points at present are so prominent, that some remarks on the subject may be taken as being needed—evidence to that effect being seen in the craftshops and the handicraft guilds. The original idea of these is presumably to make it generally possible for the home worker or handicrafter to produce better pottery, furniture, rugs, embroidery, leather work, and needlework generally, than can be made in the factories. This, of course, is hardly even controversial, but the best evidence or argument on this point that has as yet been adduced in this book. The most important point too is the effect that this book will have on the design in the artistic industries in the near future all over the universe. The author says in his preface (which is really the chief part of the letterpress) that "the interest in peasant art is really of recent date." In most cases it was only aroused when it had almost ceased to be produced. Since the beginning of the 19th century the folk-lorists of all countries have extended the sphere of their investigations to folk art, *i.e.*, to peasants' houses, national costumes, home industries, and rural arts and crafts. True, their investigations have been not so much from the point of view of art industry as from that of ethnology. It was only towards the end of the 19th century that the artistic charm of folk art, hitherto despised, began to be appreciated, and its value in connection with art history recognized.

Great international exhibitions, and smaller national ones aroused considerable public interest. Permanent exhibitions in newly-founded open air, folk art, and local museums, aimed at establishing and strengthening this newly awakened interest. Trade took up the new fashion, shops were opened to sell the products of home industries; stores installed special departments for "peasant art." And even if this novel branch of trade only sold feeble copies of what folk art had once produced, yet there was still a charm in the apparently inexhaustible wealth of motifs and ever changing ornamentations. But these goods were seldom the product of the home—in the old sense of the word—rather were they the output of a home industry, and of those practising "Arts and Crafts" who had lost the tradition or flair for real materials, and who were obliged to adapt themselves to the requirements of passing fashions. They supplied the shops according to orders. Nor did the art dealers lag behind. Country folk were only too willing to exchange their old chairs, chests, and household utensils in return for cash. Peasant women gladly sold their heirlooms, jewelry, or the shawls, kerchiefs, and fabrics they had woven and embroidered as children. The towns tempted them to spend the money thus obtained on articles that appeared both essential and desirable. Indeed, they were actually pleased to get rid of these things (of which they were almost ashamed) in such a pleasant way in order to make room for city made articles. But the peasants' pride, or rather the rural population's sense of historical tradition, was aroused. They began to set more store by their old possessions, and even declared they were not for sale. Their cupidity was aroused by the dealers' high prices. . . But when they finally recognised that their decorative works were the conscious expression of a tradition and of tradition loving families, it was too late . . . Briefly, the thread of tradition was snapped, and the fate of folk art was sealed.

The exact status of peasant art in decoration (especially ceramics) is difficult to define. Tolstoy was mainly responsible for the widespread interest manifested by his writings. In "What is Art," he cuts out (as true art "Sophocles, Euripides, Aeschylus, and especially Aristophanes; or, of modern writers—Dante, Tasso, Milton, Shakespeare; in painting, all of Raphael, all of Michael Angelo, including his absurd 'last judgment'; in music, the whole of Bach, and the whole of Beethoven, including his last period."

This is sweeping, and we have to search very closely for what he considers to be true art. We find as in a glass darkly that he considers true art to be the art of the unperverted peasant. We have again to search very deeply for what he means by "perversion." The nearest we can get is that the peasant should not be perverted by training or instruction. It is, of course, a crusade against Academic Art. The scientifically perfect figures of Michael Angelo have, for him, no place in art. The naïve, and sometimes shapeless and comic figures seen in comic art are for him the acme of artistic expression. When challenged as to the artistic standard of his own work he replies, "While offering as examples of art those that seem to me the best, I attach no special importance to my selection: for besides being insufficiently informed in all branches of art, *I belong* to the class of people whose taste has, by false training, been perverted, and therefore my old inured habits may cause me to err, and I may mistake for absolute merit the impression a work produced on me in my youth."

This all amounts to a view—always deeply controversial as to the two camps—(1) impression or suggestion; and (2) statement—literal, or idealized. This will always last while art lasts.

As for the illustrations in this book, they are beyond criticism. As to their art character—they are of a high class as regards design, which means that the design is part of the material, and emphasizes its beauties, without being an "all over" pattern to conceal its defects. Every factory which produces art work in furniture, textiles, metals, or ceramics, should possess this book, and all designers, schools of art, and manufacturers, should possess a copy. FREDERICK A. RHEAD.

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

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EDITORIAL

CERAMIC RESEARCH COUNCIL AND INSTITUTE

Editorially the *Ceramic Industry* has shown the value and a workable way of financing a Ceramic Research Council and Institute. This proposal was not made to fill editorial space nor was it fostered as an intellectual gymnastic exercise for scribes. Its sole purpose was to crystallize a determination by ceramic plant owners to collaborate in getting their just share of the tax monies used by the nation and state for research bureaus, universities, and experiment stations.

No group of producers is more backward and no one is having a harder struggle to meet competition because of quality of product and high cost of production than are the ceramic manufacturers. Because the cement manufacturers are organized to do so they are extensively employing the country's research facilities, improving their product and proving the utility value of cement. Another measure of possible state support of research in response to an organized demand is found in the average figures for the past ten years in Ohio where $135,000 annually has been appropriated for agricultural research and only $5,000 for industrial research.

When we survey the great economic urgency for fundamental and applied research in ceramics and the comparatively small amount of the public monies that is being spent in the interest of ceramic indus-

tries, we naturally seek the reason; and the lack of a unit organization of ceramic industries is the evident reason.

The ceramic industries must pay federal and state taxes. The tax rate is legislated and the tax monies are appropriated and spent by personnels employed for these purposes. Federal and state appropriations are determined and are spent by persons whose intent is to serve those who pay the taxes.

Obviously the legislators and those in charge of state supported research laboratories and schools are dependent on their tax-paying constituents for knowledge as how best to expend the money raised by taxation. Obviously too those constituent groups which are organized to best present their needs and to collaborate actively with the institutions in research will get the larger share in the appropriations.

It should be needless to emphasize our dependency on federal bureaus, experiment stations, and universities for industrial growth and strength. These institutions are essential means for obtaining and for enjoying material prosperity. And material prosperity is essential to that intellectual and spiritual progress which collectively is termed civilization.

It should be needless to repeat that the material prosperity enjoyed by a person or an industry is proportional to information obtained and used.

To convert into cash the value which there is in general information one must make specific application of knowledge. For instance, knowledge of the immiscibility in silicate fusions is of large cash value to every ceramic plant and the sooner and the more intelligently such knowledge is applied specifically to ceramic problems the greater cash value will the ceramic industries realize from the large sums of money which are invested annually in support of research and educational institutions.

The providing of a $1,000,000 research endowment rests alone on a determination on the part of the ceramic manufacturers to provide ways and means of getting the largest possible returns from the investments they already have and continually are making in public research and educational institutions.

These institutions have the necessary facilities and directing personnel and are collaborating with those industries which are organized and financed to collaborate.

The interest obtained from this $1,000,000 endowment would finance "fellowships;" that is, it would make possible the securing of advance degree students who would direct their studies and research to specific ceramic problems. They would study ceramic materials, products, and processes. They would determine the application to ceramic problems

of known fundamental facts. They would employ the X-ray, the microscope, the chemical methods, and so on, in analysis and synthesis. Their work would be specific in its industrial application, yet wholly fundamental.

With a council comprised of one or more full time research advisors supplemented by a cabinet of technical men in the industries, these fellowship studies would be focused on the many fundamental problems which arise in every practical process or product study undertaken by the trade associations. These fundamental problems are continuously listed and only partially solved. Available time, talent, and facilities have seriously limited the proportion which has been applied to ceramic problems from the vast fund of known fundamental facts.

It requires a council, such as is proposed, to coördinate the fundamental with the applied investigations and only when such a council is provided will it be possible to formulate to the several research laboratories the fundamental problems of immediate value. These problems will not otherwise be generally known to the research staffs of our public research institutions.

To employ in ceramic research the federal and state research facilities to the extent warranted by the supporting taxes paid annually by the ceramic industries, the ceramic industries must do two things: (1) finance fellowships, and (2) provide a coördinating council.

On other occasions emphasis has been given to the value of such a Research Council in making application studies in the plants and laboratories. The several groups singly are now spending money on such problems. These studies would be expedited, their cost lessened, and the benefits increased through coördinated advisory service to the several financing groups and prosecuting laboratories.

There need be no sacrificing of privacy or control on part of each industrial group in the investigations which they may finance. And certainly there would be no directing of nor dictation to the laboratories.

The only objection voiced to this scheme of a coördinating Advisory Council is the seeming divergence in interests of the several and separate industrial ceramic groups. It is difficult for some to see the value of glass manufacturers coördinating with brick manufacturers in research. As a matter of fact, this divergence in scientific research between the several ceramic industries is not real.

In the successful functioning of the AMERICAN CERAMIC SOCIETY and of the ceramic division of the Bureau of Standards where these several seemingly widely divergent interests are coördinated, there is evidence sufficient, it would seem, that each and all would profit. The Ohio Ceramic Industries Association is successfully functioning for the

brick, the pottery, the glass enamel, and the glass industries of Ohio in education and research. There is strength in such a ceramic coördination and no demonstrated weakness. Divergence in product is not evidence of want of commonage in technical and scientific interests.

We second the motion made editorially by *Ceramic Industry* that the several ceramic groups organize a Ceramic Research Institute and loan $1,000,000 without interest for a period of ten years in support of fundamental studies.

We are pleased to have support of our previous suggestion of a Ceramic Research Council the function of which would be to advise the laboratories and the industrial groups on research problems.

The two can profitably be combined. If the Institute is deemed too ambitions for the present we urge support of the Council idea. Other countries have such ceramic councils and in America we have large corporations with extensive private research laboratories contributing large sums of money to the support of the National Research Council. This therefore is a tried idea, with proven value. To delay in forming a Ceramic Research Council means handicapping the ceramic industries in their economic race for profits and stability.

PAPERS AND DISCUSSIONS

THE NECESSITY FOR OPERATING STANDARDS AND PROCEDURE CONTROL IN THE ENAMELING INDUSTRY[1]

By Robert D. Landrum

The Iron Base

Enameling is only one of the operations that sheet steel must undergo. The sheet must be suitable for the various forming and welding operations as well as for enameling.

The first routine test is to check uniformity in gage.

Standards should be established as to the breakage allowable in each operation and with certain dies, and records should be maintained that the man in charge can be kept completely informed. Such records form a better basis for valuing a particular make of sheet steel for a specific purpose than any physical test yet devised.

Careful records for each step in the process are data far more valuable than the results of any laboratory tests that could possibly be devised. They form a definite basis for procedure control.

Sheets of different gages should be stored separately. The various shipments should be stored separately, marked, and perpetually inventoried with data on the process performance and full information regarding each lot of sheets as furnished by the producer of the sheet. This will also assist in uniformity of product by insuring that ware of several gages and quality are not, in error, going through process simultaneously.

Regarding the Composition of the Iron Itself

Enameling plants equipped with chemical and metallographic laboratories are examining their enameling stock regularly. The manufacturers of the iron base are more than willing to coöperate and advise. Their laboratories are always available to their customers. The most expert advice can and should be obtained whenever trouble seems to be chargeable to the sheet metal.

Test No. 1 in Mr. Rice's report,[2] covers the usual determinations made in a laboratory examination of the iron base. Metallographic examination will probably give more information in most cases than will chemical analysis.

The Black Shape

Design

The design of the black shape has much to do with creating public demand. It also affects production costs due to such factors as breakage in forming, number of operations necessary, and

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Enamel Division.)

[2] Bryan A. Rice, "Factory Control Tests," *Bull. Amer. Ceram. Soc.*, 5, 241–51 (1926).

defects in the enamel coating traceable to the design. The designer should have the counsel of those in charge of the enameling operations. Also, he should have coöperation from the sales department, for the part the design plays in the public's buying is tremendous. A trained artist should have his part in this counsel, but his inspirations must be made practical by those who understand the process completely.

Annealing Each step of the forming processes should be under careful control. Where annealing is necessary to facilitate deep-drawing, the temperature of the furnace and the time of annealing are important. Definite standards should be set and maintained.[1]

Dies The maintenance of the dies and lathe tools is important. The black shapes must be uniform and their surfaces as smooth as possible. It is practically impossible to make a saleable finished product from a poorly made shape.

Lubricant The lubricant used in the forming operations should be chosen not only for its lubricating qualities but also for its ease and economy of removal. Definite specifications for this lubricant should be established and adhered to. The tests are well known.

Conditions of Shapes Operations and conditions in the stamping department should be such that the shapes are kept clean, free from dust, and as free as possible from rough edges. Any rough edges should be removed before pickling. Records should be so kept that if trouble subsequently develops it can be easily traced.

Preparation for Enameling The various cleaning operations demand especially careful control. Whether the grease is removed by burning off or by boiling in strong alkali bath, definite standards should be set up as to the time and temperature of annealing and as to the strength of the alkali bath and its maintenance.

Even the rinsing solutions in the pickling process should be kept under careful control. It is a general rule that within limits, the more water used in the pickling department per ton of sheet steel pickled, the fewer subsequent troubles there will be. Thorough washing of black shapes between the first caustic wash and the acid is absolutely necessary to minimize the amount of acid used.

The washing after the pickling bath should be quick and thorough.[2]

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[1] Julius Grünwald, "Annealing and Pickling of Finished Iron Articles before Enameling," *Stahl u. Eisen*, **29**, 137 (1909); *Chem. Abs.*, **3**, 878 (1909).

[2] If any sulphuric acid remains on the ware, sodium sulphate is left as a coating after the shape is dried. This will fuse during the firing of the ground coat, and come to the surface. It will not be noticeable until the first white coat is applied. At each spot on the ground coat where the salt is accumulated, it will usually cause a parting of the white cover enamel allowing the ground coat to show through in spots. Sometimes, in damp weather, this sodium sulphate becomes visible on the ground coat, as it changes from the anhydrous to a crystalline form. It should be noted, too, that delay in transferring the black shape from the rinsing to the alkaline bath is liable to cause many enamel defects.

Tests from time to time should be made to determine the alkalinity or acidity of the rinsing solutions.

The final weak alkaline solution in which all enamelware is boiled[1] just before drying, is one which probably needs a more careful control than any other solution in the cleaning process.

It is important to control the temperature of the bath. It must be kept boiling vigorously.[2]

The strength of the alkaline solution, its temperature, and length of time of boiling the black shapes should be standardized. The quick drying operation after this boiling in weak alkali is also important.

Inspection of the black shapes after drying should be made by a competent and alert man.[3]

Extent of Pickling

With each black shape, experiments must be made to determine the length of time necessary for thorough pickling. It has been found more of a detriment to overpickle than to deliver dirty ware to the enameling department, for the latter is easily caught by the inspector. Overpickling is especially dangerous and undesirable because its effects are not so easily traced to the pickling. The results of overpickling sometimes do not make themselves evident until the first coat of enamel is applied, and sometimes even later than this. Many times, effects from overpickling do not show up until the second or third coat is applied.

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[1] One of the functions of this bath is to neutralize any acid which might remain on the sheet and cause rusting. It has another function which is probably more important than the neutralization. This second function is to aid in the eliminations of the hydrogen gas taken up during pickling.

[2] Both Treischel ("Cause and Control of Blistering in Sheet Steel Enameling," *Jour. Amer. Ceram. Soc.*, **2**, 774 (1919)), and Ph. Eyer, ("Natural History of Enamel Defects," *Keram. Rundschau*, **20**, 233, 243–52 [1912]; *Chem. Abs.*, **6**, 3505 [1912]) conclude that this occluded hydrogen is one of the causes of blistering. (G. A. White, Metallurgical Study of Steel Base as Related to Galvanizing, Titanium Alloy Mfg. Co., Book. 1918.)

[3] Iron oxide left on them in the form of Fe_2O_3 will possibly cause copperheads, as this oxide is incapable of forming silicates at muffle furnace temperatures. (Camp and Francis, Making, Shaping, and Treating of Steel, p. 233.)

As far as the pickling solution itself is concerned, much work has been done, and definite data is available as to the best strength and temperature of acid solutions, and the length of time necessary in pickling different shapes. Similar data should be obtained of this operation in each separate plant from careful records kept. Where observations are made as a part of plant control and this data recorded, the very operation itself is research work for control standards. An intelligent man can draw more valuable conclusions regarding necessary standards from such data than could ever be drawn from results obtained in a laboratory. Rice has given in this report under tests Nos. 2 and 3, the usual methods for the control of the acid solution. Danielson (R. R. Danielson, "The Cleaning of Sheet Steel and Iron for Enameling Purposes," *Jour. Amer. Ceram. Soc.*, **2**, 890 [1919]) also describes a method for titration versus alkali. See also article in *Enamelist*, **1**, 8 (1923), regarding pickling pills.

B. A. Rice,[1] defines "control" as the employment of certain mechanical or chemical means whereby one or more factors in an enameling operation become fixed so that by eliminating the variable greater ease in duplication of conditions becomes possible. I do not adhere to this definition.

By "control" I mean "procedure control,"[2] which includes all elements which may be considered as essential to procedure, namely, design, materials, methods, operators, supervision, as well as tests, and also the records that are kept to give information as to the cause of defects in each and every operation.

The Enamel Frit

The raw materials can be divided into three classes:

Class 1 Those which are nearly chemically pure and unaffected by atmospheric conditions: quartz (ground quartz sand), fluorspar, whiting, kryolith, tin oxide, zirconium oxide, antimony oxide, antimonate of soda, cobalt oxide, manganese oxide, nickel oxide, zinc oxide, magnesium carbonate, and aluminum oxide.

Class 2 Those nearly chemically pure, but affected by varying weather and storage conditions: borax, soda ash, nitrate of soda, and nitrate of potash.

Class 3 Minerals naturally varying in composition: feldspar and clay.

Each material should be bought upon specification as to composition and fineness. Standards for these should be evolved in coöperation with the supplier; the cost element requires this.[3]

The materials coming under Class 1 need less attention than the others, for they are easily obtainable in pure form, and as we have stated, are unaffected by atmospheric conditions.

Provision for making certain determinations on the materials in Class 2 however, should be arranged for in every enameling plant. Borax, under certain conditions, will vary 20 to 40% in its water content.[4]

If the borax is carefully stored so that it is not contaminated by soda ash dust, a simple alkalinity determination with a standard acid solution and methyl orange used as an indicator is sufficient. From this, the actual amount of $Na_2B_4O_7 \cdot 10H_2O$ present can be calculated.

Soda ash, while it varies within smaller limits than borax, also requires the determination of its alkalinity for routine control.

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[1] *Loc. cit.*

[2] S. W. Miller, "Procedure Control (Welding)," *Iron Trade Rev.*, **80**, 386 (1927).

[3] In general, it is well to pay for uniformity, *i.e.*, to buy the highest refined article practical. For instance, if acid grade fluorspar, Class 1, is used, its calcium fluoride content can only vary 2%, while the next grade varies ±5%. Specifications for these are necessary, and their control, either by analyses from time to time in plant laboratories or in commercial laboratories, is desirable.

[4] E. P. Poste, "Manufacture of Enamel Lined Apparatus," *Jour. Amer. Ceram. Soc.*, **2**, 903 (1919).

The moisture in both the nitrate of soda and nitrate of potash should be determined. Methods for these determinations are given in a paper by the writer.[1]

Feldspar The two minerals in Class 3 need the most control. It is almost impossible to get either feldspar or clay that is uniform from shipment to shipment . When we consider the large proportion of these raw materials used in the enameling process, we begin to realize the tremendous effect of any variation in them upon the enamel coating. Every carload of feldspar, therefore, should be analyzed, care being taken that the sample is representative of the carload. It has not been found necessary to make complete analysis of each carload when the feldspar comes from the same mine, for the lack of uniformity is generally due to the amount of quartz present. Simply a silica determination may be made. Any difference in this from the standard is due to the fact that either more or less quartz has been ground in with the original feldspar. From this figure, calculations can be made for changing the batch mix.

When a new feldspar is used, a complete analysis must be made, and the batch mix accordingly adjusted.[2]

The feldspar should be inspected for free iron by the use of a magnet.

Feldspars will vary in color due to the presence of combined iron. Comparison of color with the standard should be made.

The specifications for feldspar should include fineness and should be checked by screen tests.[3]

Clay As this material is used raw in the mill and varies in composition both on account of nonuniformity in the material as mined, and on account of storage conditions, it causes more trouble in enameling than any material used. It is a very difficult problem indeed to draw up specifications for enameling clay, for both the compo-

[1] R. D. Landrum, "Methods of Analysis for Enamels and Enamel Raw Materials," *Trans. Amer. Ceram. Soc.*, **12**, 144 (1910).

[2] E. H. Watkins (*The Enamelist*, **2**, 17 [1925]) explains in an article why a variation even as small as 3 % of SiO_2 in feldspar will cause such a wide variation in the workability of enamels. Staley ("Suggestions for Developments in Enameling Technology," *Jour. Amer. Ceram. Soc.*, **7** [10], 725 [1924]) says that probably the greatest avoidable loss in enameling of metals is that due to the variation in feldspar. He speaks of the variation causing great changes on the coefficient of contraction. He even goes so far as to suggest that it might be well to evolve formulas in which no feldspar is used. He insists that accurate analyses of the feldspar are necessary whenever this material is used.

[3] In general with both feldspar and quartz, the more finely divided the material the better, as this will reduce costs on account of the shorter time of smelting required. This in turn has its effect on increasing the opacity of white enamels. References of interest regarding the control of feldspar are (1) E. H. Watkins, *Enamelist, loc. cit.;* (2) H. F. Staley, *Ceramist*, "Principles of Enameling," **4**, 87 (1924), Discussion, "Free Quartz in Feldspar," *Ceramist*, **7**, 81 (1925).

sition of the clay itself and its physical properties enter very largely into the matter. We have great hopes that the work now being done with adaptations of the Bingham Plastometer will give us illuminating data. Even after this is obtained, it will still probably be found necessary to blend several clays to obtain desired results.

One of the most important suggestions I can make at the present time is that when a good working clay has been found, a quantity of it be purchased that will last for a long time.

Every enameling plant should be equipped to determine the excess of moisture in the clay. From this, the correct amount of clay to be added at the mill should be calculated.

Storage of Raw Materials An important part of procedure control is the establishment of a system for storing the raw materials. With all classes of materials, suitable arrangements should be made so that there will be no chance of confusing the materials.

Cleanliness is certainly important. This applies especially to storage facilities.

With the materials in Class 2, the storage facilities should be such that as little variation due to atmospheric conditions as possible will result, *i.e.*, tight bins away from heat and excessive moisture.

With the materials in Class 3, minerals varying from shipment to shipment, it has been found advisable to store each shipment in separate bins. *Records should be kept so that if a new lot of material has any effect on the resulting enamel, its source can be traced.*

Weighing the Batch It is well to have the batch mixes of such size that an even number of bags of borax can be used. This is especially important in plants that do not analyze their borax and make corrections for variations in the moisture content. Producers of borax will furnish bags containing exactly 100 pounds pure borax crystals.

Periodic checking of the scales is necessary, as well as the checking of tares. There is nothing more important than having the enamel batches weighed by the man responsible for the enameling process. He should make the calculations for variations in the materials, and be responsible for making the necessary changes.

Mixing the Batch This procedure is well worth standardizing. No matter what method is employed in mixing the batch, a regular check should be made as to uniformity of mixture. This can be done in a rough way by making alkali determinations upon samples taken from various portions of the mixed enamel. Instead of an alkali determination, sometimes a determination as to the percentage soluble in water is used.

Smelting It is well to have the smelter load correspond to the batch mix. This will minimize the danger of producing nonuniform enamel on account of nonthorough mixing.

Periodic examinations of the condition of the furnace lining should be made.

The smelting furnace should be under pyrometric control. The temperature of the furnace before charging should be such that the charge will not cool it below the proper smelting temperature.

Smelter control should include making certain complete combustion of fuel, especially when reducible materials such as lead, tin, or antimony are contained in the batch.[1]

Where the reverberatory smelter is used, the amount of stirring necessary should be predetermined and adhered to.

The metal stirring rods used should be kept hot, and most plants have found it good practice to put aside any of the enamel adhering to these rods.[2]

A definite time-temperature constant should be determined for each enamel. With white enamels it has been found desirable to have the furnace at as high a temperature as possible with the refractories obtainable, so that the length of time in the furnace will be as short as possible.

Methods should be devised for determining definitely the moment at which the batch is properly smelted.[3]

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[1] Opinion is divided as to the advantages of revolving or rocking smelters over the ordinary reverberatory smelter. The former do have the advantage, however, of keeping the enamel stirred without the contamination from stirring devices.

[2] The iron scale adhering to the white enamel broken from these rods would most certainly cause dirty enamel. Chunks of unquenched enamel in the mill addition make uniform grinding impossible. These discarded pieces of enamel can be saved and resmelted together with unquenched lumps from smelter troughs which will be brought up later.

[3] Some of the old methods are as good as any: observation of the condition of the surface of the enamel; freedom from lumps on threads of enamel drawn from the molten batch with tongs. Rice in his questionnaire (Rice, *loc. cit.*) suggests that deformation test (Test 5) may be used to determine whether or not the enamels have been properly mixed and smelted. Adaptations of Poste's and Geisinger's microscopic examination of enamel may well be used, too. (E. P. Poste, "Enameling Surfaces under the Microscope," *Trans. Amer. Ceram. Soc.*, **19,** 146 (1927); E. E. Geisinger, "Microscopic Study of Ground Coat and Cover Enamel Reactions," *Jour. Amer. Ceram. Soc.*, **5,** 322 (1922), and Discussion, *Bull. Amer. Ceram. Soc.*, **1,** 112 and 162 (1922).) The bubbular structure of samples drawn from the furnace will give illuminating information. W. A. Denmead ("Hints on Experimental Enamel Making," *Trans. Amer. Ceram. Soc.*, **16,** 447 (1914)) calls our attention to the fact that much can be told about the condition of the smelt by the viscosity of the molten enamel as it runs from the furnace. See also Poste and Rice, "Effect of the Degree of Smelting upon the Properties of a Frit," *Jour. Amer. Ceram. Soc.*, **1,** 221 (1918) and Ph. Eyer, "The Melting of Enamels," *Ill. Ztg. Blecking*, p. 640, 1912; *Chem. Ztg. Rep.*, 36, 654.

Quenching It will assist greatly in standardizing the milling practice and in keeping the enamel uniform all along the line, to control carefully the quenching of the enamel. As a general axiom, it may be stated that the more quickly the enamel is cooled as it runs from the furnace, the better and more uniform the resulting product will be. Economizing on water at this point is expensive in the long run. Large outlets to the water tanks and large volume of water running into the tank are factors that will assist in keeping the physical characteristics of the frit uniform. Also, the time and cost of milling will be reduced to an extent that will more than pay for the excess of water used. Jets of water, air, steam, or combinations of these, playing upon the molten stream of enamel, assist. The method suggested by Athenstaedt[1] for the disintegration of blast furnace slags and enamel frit is good.

In plant laboratories, it is well to include in the equipment a power agate mortar. This has many uses. It can be used to determine the degree to which the frit has been quenched. The time necessary for grinding a small, weighed quantity of this frit to the point where it is impalpable and, therefore, emits no scratching sound, is indicative of the degree to which the frit has been quenched. The shorter the time the greater the degree of quenching. Based on this test, the time of milling can be either shortened or lengthened, according to the standard.

Any enamel which is not well-quenched, together with the tongues of enamel which harden on the smelter exit should be thrown aside for resmelting, as the introduction of this hard material into the mill will make uniform grinding impossible.

Storage of Enamel Frit It is well to drain the frit completely before it is charged into the mill. It is best to have the frit thoroughly dry. The moisture content of the frit should be determined and calculations made accordingly for mill mixing.

Records showing the actual loss in smelting, (*i.e.*, the difference between the weight of materials used and the weight of the dry frit obtained) will assist in establishing standards. *Records showing each change in formula and each change in raw materials are absolutely necessary.* Frits in which such changes have taken place should be kept separate from foregoing frits, and the enamels resulting from these kept under special observation.

Milling Definite standards have to be set up for each mill, the size of charge, weight of pebbles, approximate size of pebbles (size at which pebbles should be discarded) carefully regulated.[2]

[1] "Cooling and Disintegration of Blast Furnace Slag and Enamel Frit," *Keram. Rundschau*, **34**, 538 (1926); *Chem. Abs.*, **20**, 3220 (1926).

[2] See R. L. Cawood, "Modern Pebble Mills," *Enamelist*, **3**, 19 (1926); "Efficiency in Wet Grinding of Enamels in Ball Mills," *Ceram. Indus.*, **6**, 183 (1926); E. W. Lawler, "Practical Dissertation on Pebble Mills," *Ceram. Ind.*, **2**, 369 (1924); "Design and Operation of Ball and Pebble Mills," *Chem. Met. Eng.*, **30**, 517 (1923).

Careful weighing of the mill batch is just as important as weighing of the batch to be smelted. This is not generally recognized.

The water added at the mill should be weighed rather than metered. Periodic determinations should be made of the percentage of water in the enamel as it comes from the mill.[1]

In general, it has been found well to use a minimum rather than a maximum quantity of water in grinding, so that the resulting frit can be brought up to its proper consistency by the addition of water rather than by the use of salts.

Where electrolytes are added at the mill, special care should be used in seeing that the amount predetermined as correct is added.

The time of grinding will in a measure determine the fineness of the finished enamel, but we must remember that each mill has its own factor.[2]

The degree to which the enamel has been shattered, *i.e.*, the degree of quenching, also largely determines the length of milling necessary.

Some plants have found it desirable to use mills mounted on rollers at one end so that samples can be taken from an opening in the center of that end of the cylinder, even while the mill is running.

Data as to the degree of fineness can be obtained by the determination of the amount of enamel retained on a certain mesh sieve. Cooke has given a good method for determining the degree of grinding.[3]

Probably the ultimate test that will be used to determine whether or not the wet enamel from the mill is in the best condition possible for

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[1] Plants, upon inaugurating this test, will be surprised at the variations in the water content and at the change for the better in their product as soon as this is kept more constant.

[2] H. B. Gray, in his article on "Hours vs. Revolutions in Grinding," (*Enamelist*, **2**, 15 [1925]), calls attention to the use of a revolution counter, basing the length of grinding upon revolutions rather than upon hours. This eradicates errors due to variations in the electric current supply or to belt slippage.

[3] R. D. Cooke, "Fineness Test for Pebble Mill Control," *Enamelist*, **2**, 11 (1925). Fifty grams of the enamel slip are weighed and washed into a 100 cubic centimeter glass stopper graduated cylinder. An excess of sodium silicate is added, and the whole made up to 100 cubic centimeters with water; the contents thoroughly mixed by shaking a few seconds; the cylinder is then placed upright and allowed to stand exactly one minute. The frit particles settle freely at this point at a rate depending upon their size, and form distinct layers at the bottom of the cylinder. The number of cubic centimeters at the end of one minute or any other predetermined time is an index of the fineness of the enamel. The clay remains in suspension. See also B. T. Sweely and E. S. Prince, "Relation of Fineness of Grinding to Opacity in White Enamels," *Jour. Amer. Ceram. Soc.*, **5**, 12, 855 (1922).

further operations will be developed from the work that is now being done with adaptations of Bingham's plastometer.[1]

Storage and Aging of Wet Enamel

As all enamel frits are more or less soluble, the condition of the enamel slip does not come to equilibrium until after it stands for some time. To have the enamel uniform as to many of its physical properties—yield point, mobility, etc., it is good practice to age the enamel for a predetermined length of time. This does not apply to ground coat enamels, for most of these contain dissolved borax which crystallizes out on standing. It is a saying in most plants to use ground coat enamel "hot from the mill."

Care, of course, should be taken to keep the enamel clean during storage. *Records should be kept so that should anything go wrong, the composition can be traced back to the source.*

Preparation of the Enamel for Application

This should be done by one man, preferably in the mill room. The slushers or sprayers should not be allowed to add either water, thick enamel, or electrolytes at the tank.

The manner in which the enamel drips and clings to one's finger is a crude but often used method of determining the consistency of the enamel. All the methods of determining viscosity assist, but do not give the data needed, for the viscosity of the enamel in this condition is only "apparent viscosity." Denmead[2] was one of the first to improve the old "finger method." He used a large spoon in which two holes were bored. If the enamel was of proper consistency it ran through the larger and not the smaller hole. An old European method is to place the enamel in a vessel and to tip the vessel so that the surface of the wet enamel oscillates. The number of oscillations before the surface comes to a standstill gives an indication of the "consistency" of the enamel. The use of a hydrometer has been suggested, but as it is not specific gravity but apparent specific gravity that is to be determined, data from hydrometer tests are not very satisfactory.

The time of sinking of the hydrometer is a function of the consistency of the enamel, and therefore, the time for the hydrometer to sink to a certain depth would give useful data.

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[1] See E. C. Bingham, H. D. Bruce, and M. O. Wolbach, "Plastometer as an Instrument for Process Control," *Jour. Ind. Eng. Chem.*, **14,** 1014 (1924); R. D. Cooke, "Plastic Properties of Enamel Slip," *Jour. Amer. Ceram. Soc.*, **7,** 651, (1924); E. P. Poste, "An Analysis of the Suspension of Enamel by Clay in Terms of Colloid Theory," *Jour. Amer. Ceram. Soc.*, **8,** 232 (1925); Discussion on Plasticity, *Bull. Amer. Ceram. Soc.*, **3,** 374 (1924); "Plastic Properties of Enamel Slip," *Bull. Amer. Ceram. Soc.*, **4,** 226 (1925). Reference is also made to the paper by W. N. Harrison, "Controlling the Consistency of Enamel Slips" to be published as a *Technical Paper* of the Bureau of Standards.

[2] W. A. Denmead, *loc. cit.*

Fusselbaugh and Sweely suggest that the weight per cubic foot or actual specific gravity will assist in controlling the dipping consistency of ground coat enamels.[1]

The method given by Euler is interesting.[2] A test piece is used to see that the weight of enamel per square foot is standard. It might be well to use the plastometer at this point rather than to determine whether the milling is properly accomplished. Probably this method will be used both for milling and for wet enamel control.

The application of the enamel, however, is still largely dependent upon the slusher or sprayer, and certain standards should be determined as to just how this slushing and spraying should be done. The same amount of enamel should be applied per square inch on every shape.

With spraying, control of air pressure and adjustment of nozzles is very important. Then, too, provisions should be made so that the air line is free both from water and from oil. This requires standardized inspection.

Drying

Uniformity in drying of ground coat is expecially important. The more quickly ground coat is dried without the enamel creeping, the better. Mechanical driers are generally used for this purpose. Slower drying of the second and third coats is best. The condition of the dry enamel on the ware is important.

Firing

All firing furnaces should be under pyrometric control. The temperature should also be automatically controlled in the firing furnaces, and the time-temperature treatment for each class of ware should be standardized.

The careful maintenance of points for holding the ware and automatic loading devices so that these points are kept hot all tend toward producing a uniform product. The condition of the furnace atmosphere should be noted from time to time. Leaks allowing gases to enter will cause defective ware. Continuous furnaces are now being used. The general adoption of these will do more probably than anything else to standardize the firing operation in enamel manufacture. The time-temperature factor if once determined can be controlled in the continuous furnace when the work can so be routed that pieces requiring approximately the same time of firing can be scheduled for firing during continuous periods.

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[1] R. R. Fusselbaugh and B. T. Sweely, "Method of Control of Enamel for Dipping Ware," *Jour. Amer. Ceram. Soc.*, **8**, 303 (1925).

[2] B. T. Euler, "Ground Coat Dipping," *Enamelist*, **2**, 19 (1925).

Inspection

Inspection of the ware at the end of each operation should be made. Records of these inspections specifying the percentage of rejects and tabulating where possible causes for rejection will do much as a control method. The microscopic examination of the condition of the finished ground coat and cover coats, while it cannot be used as a control method, is very valuable in ascertaining causes of trouble.[1]

It is the intent of this paper to give us a better conception of just what standards are needed, and to emphasize the necessity of routine and procedure control, and the regular keeping of technical records. It is well worth while for every member to work faithfully with the Committee on Standards in developing further control tests.

The Titanium Alloy Mfg. Co.,
Cleveland, Ohio

Control Testing of Borax and Soda Ash Stocks Used in the Smelting of Enamel Frits

By W. V. Knowles

Regarding the routine control of the borax and soda ash, this is a simple method that can be used in any of the enamel plants smelting their own frit.

These raw materials are usually chemically pure, but contain varying amounts of moisture. Therefore, the amount of $Na_2B_4O_7 \cdot 10H_2O$ in the borax stock and the amount of Na_2CO_3 in the soda ash stock should be determined at frequent intervals. To use the method of control simply means the installation of a few pieces of chemical apparatus in a well-lighted part of the mixing room. The method is so simple as to require little or no technical skill.

The method consists of titrating the theoretical amount of borax or soda ash with standardized acid solutions, disregarding the very small amounts of impurities incident to these chemicals.

It was found sufficiently accurate for routine control to use a 20-gram sample dissolved in water which was made up to a 500 cc volume in a volumetric flask.

50 cc of this solution is withdrawn with a pipette, transferred to a flask for titrating with a special standardized sulphuric acid solution, using methyl orange indicator. The sulphuric acid solution is made of such a value that if the burette reading is multiplied by 4, the percent-

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[1] E. E. Geisinger, *loc. cit.*; E. P. Poste, "Enamel Surfaces under the Microscope," *loc. cit.* E. P. Poste, "Enameled Products Research Laboratory," *Chem. and Met. Eng.*, **25**, 794 (1920); *Ceram. Abs.*, **1**, 191 (1922).

age of alkalinity is indicated. The reason for using acid of this concentration is to avoid the necessity of filling the burette but once for each titration. This, of course, necessitates the use of two separate standard sulphuric acid solutions; one for borax, and the other for soda ash. For an example, testing borax; acid used in titrating, 22 cc. Then: $4 \times 22 = 88\%$ borax as $Na_2B_4O_7 \cdot 10H_2O$. The balance, then, is almost entirely moisture. To calculate a formula requiring 100 lbs. of borax, it would be necessary to take $100/88 \times 100 = 113.6$ lbs. of the borax stock to be equivalent to the 100 lbs. called for in batch mixture.

The method for soda ash is much the same except that a sulphuric acid solution must be of a different value than that used for borax. The use of a 20-gram sample obviates the necessity of an expensive sensitive balance.

The complete outfit consists of the following: one balance complete, one 20-gram weight, one burette stand to hold 2 burettes, two 500 cc burettes, two 250 cc Erlenmeyer flasks, one 500 cc volumetric flask, one 50 cc pipette, one 4-inch spatula, one bottle methyl orange indicator solution, one 60 cc dropper bottle for use with indicator, two screw clamps to control filling of burettes, two rubber stoppers with glass syphons for the carboys, including extra rubber tubing and glass tubing for connecting with burettes, one 2-gallon carboy special testing acid for borax and one 2-gallon carboy special testing acid for soda ash.

We received so many requests for assistance to install this equipment and prepare the standard solutions, that we prevailed upon T. A. Patterson of the Patterson Laboratories, Cleveland, to assemble all the necessary apparatus in the form of a kit with special detailed instructions. This kit has been used by several companies with good success.

Examples of Actual Plant Tests

No. 1. Soda Ash from Stock Stored in an Open Bag in a Damp Place (Titration) — 19.2 cc for an aliquot portion of sample solution containing 20 grams

$$19.2 \times 4 = 76.8\% \ Na_2CO_3$$

If the batch for smelting calls for 70 lbs of soda ash, it will be necessary to take $70/76.8 \times 100$ or 91 lbs. of the stock on hand.

No. 2. Borax from a Stock in Open Bag Stored in a Damp Place (Titration) — 21.3 cc for an aliquot portion of sample solution containing 20 grams

$$4 \times 21.3 \text{ or } 85.2\% \ Na_2B_4O_7 \cdot 10H_2O$$

If the batch for smelting requires 250 lbs. of borax, it will be necessary to take $250/85.2 \times 100$ or 293 lbs. of this stock.

No. 3. Borax from Stock Kept in Warm, Dry Storage (Titration)	28.7 cc. for an aliquot portion of sample solution containing 20 grams.

$$4 \times 28.7 = 114.8\ \%\ Na_2B_4O_7 \cdot 10H_2O$$

If the batch for smelting calls for 75 lbs. of borax, it will be necessary to take $75/114.8 \times 100$ or 65 lbs. of this stock.

TITANIUM ALLOY MFG. CO.,
CLEVELAND, OHIO

USE AND ABUSE OF POWER IN HEAVY CLAY PRODUCTS PLANTS[1]

BY C. A. MILLAR

ABSTRACT

The use of crude power supplying contraptions by many small plants has been observed. The installation of water softening plants as a means of reducing power costs is suggested, as is the use of electric motors to drive individual units such as grinders or dry pans.

Power, what a word to conjure with and its application to our everyday life as we know it today. Can you picture or can the mind of man conceive what this earth of ours would be like with no power of any kind available? Did you ever stop to think for a moment as you say to your workman "turn on the power" from whence it all originated, for time was and not so very long ago when that could not be done.

Our forefathers a few generations back knew no power but the wind and water and these were crudely used to drive their boats or turn a small water wheel. An idea was the beginning of this great revolution that has been to mankind such a boon.

Picture a man sitting in his kitchen in England a few hundred years ago smoking his clay pipe and waiting the boiling of a kettle to make a cup of tea. As he sits half-dreaming the kettle begins to simmer and as the steam accumulates the lid lifts and he recognizes at once that if this power could be controlled it might be useful. From this idea came the invention of the steam engine by Jas. Watt. This was the beginning, but the end is not yet in sight.

The inventive genius of each succeeding generation has added greatly to the first idea and today power is made from almost as many sources

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[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., Feb., 1927. (Heavy Clay Products Division.) Received January 17, 1927.

as can be imagined. Steam, water, natural gas, gasoline, electricity, and many other sources of power not so well known to us all revert to the original idea of storing energy for use as we may require it.

The horse has always stood as man's friend and helper in all kinds of work and greatly eased man's burden in many ways, but he becomes tired by constantly expending energy and requires rest. Man demands something that will not tire and he has created horses made of cast iron and steel and fed with gasoline that will work twenty-four hours a day and not tire. However, the horse has earned his monument, for all energy today is measured by horse power. While there is great difference in the electricity and steam as to lifting a certain weight one foot in a given time, yet it is horse power. Now as to the application of some of the different kinds of power to the plants with which we are connected and its uses to us.

Power in Clay Plants

In my travels through Ontario and many states of the Union I have seen some of the most crude contraptions for manufacturing power that could be imagined and all because they were supposed to be cheap, but what a price many of them paid. An old rusty engine used in the fall of the year for threshing purposes and left outside the remainder of season, with tubes coated with scale one-half to three-quarters of an inch in thickness and never inspected by any competent man, was used in many cases to supply power. Some people will say that this must be in a very small plant, which is true, but why burden the small brick and tile manufacturers with such a load. I am sure that even in the larger plants for brick and sewer pipe, as a rule they were not much better off until very recently and many still are paying dearly to feed the scale parasite in their boilers.

This scale can be eliminated at a very small cost comparatively by the installation of a water-softening plant which extracts all lime from the water before it enters the boilers.

Water Softening In our own plant we have saved in the past three years at least two tons of coal per day which alone means over three thousand dollars annually and the installation cost was $1250.00.

Unit Electric Drive In larger plants where over one hundred horse power is used and possibly more required it is sometimes good business to install a motor on grinders or dry pans and run it as a separate unit thereby saving the installation of another boiler as they are expensive things to feed. Where electricity is used altogether in manufacturing and a large volume is required in order to keep down the peak load it will be found good practice to run part of

the plant at night; the grinding outfit or some part as suited to your needs.

About twenty years ago I purchased a brick plant and proceeded to install an electric motor to drive the machinery. So far as I know that was the first installation around this part of the country and many a laugh was on me by the older brick men around Toronto. The old saying "fools rush in where angels fear to tread" was again true for I was new at the business; but I have lived to see the universal use of electricity in the heavy clay products business and there is no doubt that electric power when steam is not necessary for drying purposes is by far the cheapest and cleanest that can be found.

Statistics prove beyond the shadow of doubt that steam generated under ordinary working conditions is a rather expensive way of supplying energy. In our own plant we have three one hundred horse power boilers and according to the best available figures the amount of coal we use every twenty-four hours (one boiler) should supply all we require for our one hundred and fifty horse power engine. Where is the remainder? Part of it is used on our presses and the remainder escapes in exhaust and waste although we do not have a leaking steam pipe in the plant.

While the plant is no model it is always kept in A1 condition as far as we can in regard to power. Our boiler tubes are as clean as the day they were manufactured and kept so by our water softening plant. Brick work is annually gone over carefully and all necessary work done, but the setting was all wrong according to practice and statistics of today. About two years ago we were compelled to put in one new boiler and at the same time we raised all three from two feet from the grate bars to boiler bottom to three feet six. It would have been better to have had it raised another six inches, making it four feet, as that is about right height for hand firing.

Salesmen for mechanical stokers can prove that in small plants a great deal of money can be saved by installing their pet stoker but after a careful survey and inspection of different types I am forced to the conclusion that up to five hundred horse power boiler capacity hand-firing is the cheaper, as there is very small chance of having an investment returned. A fireman has to be employed, stokers or not, and I have in mind some plants where the fireman is busier keeping things in shape and wheeling ashes than before they were installed. There is no doubt that some may not agree with these views. They are my observations of over twenty years experience in brick and sewer pipe plants.

Ontario Sewer Pipe and Clay Products, Ltd.
Mimico, Ont.

SURVEY OF THE ROYAL COPENHAGEN PORCELAIN WORKS[1]

By Dalgas

The invitation to address the members of the American Ceramic Society in my capacity of Director of The Royal Copenhagen Porcelain Works, is an honor to the Works and our artists, for which I express my respectful and sincere thanks. This invitation is no doubt based on the ceramic work done by the Royal Porcelain Works during the past fifty years to find new ways and new beauties in the great, comprehensive, and varied realm of ceramics.

History of the Works

The Royal Porcelain Works was founded in 1779 by the then Dowager Queen Juliane Marie, who gave the Works the mark of the three wave-lines indicating the three Danish waters: the Great Belt, the Little Belt, and the Sound.

The technical leader in 1779 was Franz Heinrich Müller, and he and his artistic coöperators, especially C. Luplau, toward the end of the 18th century created a series of new creations in porcelain which still compel our most profound respect. At that time the Works was working within narrow bounds, limiting itself to the white hard-fired porcelain, and was plainly under the influence of the large and powerful porcelain works at Dresden (Meissen), this being the first European porcelain works. But in spite of the many points which Meissen and Copenhagen had then in common, Copenhagen has always maintained a distinctive stamp of its own, a certain reserved gracefulness. There is more keeping to it, more style, a certain somewhat cool refinement which has been recognized more and more, this having made the very great reputation of the old porcelain from that period.

In the beginning the product was overglaze porcelain figures, vases, and ornaments. Dinner sets were made, decorated with beautiful floral painting; small coffee and tea sets with allegorical representations of mythology. These now are found only in museums. The same porcelains are still made and are treated with the greatest reverence. The present ware is known as "Juliane Marie Porcelain" in honor and memory of that earliest period.

But not only was that period occupied in overglaze; it was as much occupied with underglaze in which the so-called bluefluted porcelain, the so-called large-flowered porcelain was created, which exists up to this day, and which has, indeed, attained to an extension and develop-

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Art Division).

ment unthought of at that time. More than 2000 models belong to this set.

Next follows a period which, but for a single artist, Gustav Hetsch, should preferably remain unmentioned, as artistically as well as technically it was a period of deterioration.

But the year 1883 institutes another epoch.

Up to that time the Royal Porcelain Works of Copenhagen had been located in the heart of old Copenhagen, but now this location could no longer for sanitary reasons be maintained. In 1883 the Works moved out into the vicinity of Frederiksberg Castle with the magnificent park. As a director it got one of the great men of the ceramic world, Philip Schou. Through his genius, his wide horizon, his artistic talents, and his technical superiority, in the course of twenty years he regenerated the deteriorating old works, converting it into a new great factory.

He did not do so single-handed; he had his valuable coöperators. Expecially I am thinking of his colleague, the artistic leader, Professor Arnold Krog, who knew how to artistically elevate the material along entirely new channels.

But art and science must assist each other, and Philip Schou provided for Professor Krog new ovens of a very special construction permitting a process of firing at a higher temperature than had hitherto been known, thereby creating a wider range for new glazes, new beauties in the glaze, new colors. All of this helped Professor Krog in his work.

At that time a revival in art occurred, and not least in Scandinavia, where a number of prominent artists in their profound delight at nature and their fresh comprehension of this nature, created an unparalleled beauty in the decorative art. Krog was one of this circle, and it was granted to him, with his artistic co-workers, who were soon connected with the Works, to create an entirely new style.

He created jars, vases, and dishes which he decorated with Danish scenery, be it seascapes, landscapes, birds, animals, air, water; he included everything, the greatest and the smallest, creating therein on the excellent material placed at his disposal by Philip Schou, an art which at that time appeared as a revelation, and which completely changed the view of ceramic art throughout the world.

It was at the Paris exposition that this porcelain was first presented to the public, and it was the introduction to an artistic era undreamt of here in Denmark, which pointed to the right way to further development, further struggles, further victories.

Philip Schou was not the man who allowed a thing to remain at a result once accomplished. He worked on powerfully, so that on his retirement as director in the beginning of the 20th century the Works

stood in the very first line among the European porcelain works, with an unparalleled staff of workers and artists. This was proved to him to the fullest extent on his retirement, through the homage paid to him by the entire world, a homage well deserved.

That whole period, the Schou-Krog period, was absolutely an era of the porcelain and of the underglaze decoration. It was the task of his successor, maintaining to the fullest extent the great traditions, and in the deepest reverence of them, to strike into other and new paths, and that was done.

With the beginning of the 20th century the Works resumed a renaissance in surface-glaze painted porcelain. The first step was to resume the old models from the 18th century; to find the same colors which had been entirely abandoned; in other words, to endeavor to attain to the same level as one hundred years before. The endeavors were successful, but that was not sufficient.

New paths should be struck. Carl Martin-Hansen, who created his beautiful figures in national costumes from all parts of the country, was connected with the Works, as was Gerhard Henning, who, with his admirable technique in his exquisite groups introduced an entirely modern overglaze decoration heretofore unknown.

How the study of overglaze and the success achieved was utilized for further development, is particularly expressed in our gray crackled porcelain—by Thorkild Olsen and N. Tidemand with their assistants, under the new artistic director, Chr. Joachim. It was first exhibited at the world exposition of decorative art in Paris, in 1925.

Another path was struck by the artist A. Malinowski, who created a series of magnificent figures which he decorates with only a little gold and sepia, but in the main allows the white porcelain to appear as part of the decoration. His is a new creation, possessed of a gracefulness, refinement, and at the same time quite a strong artistic view, which is perhaps after all the underlying principle of ceramic art.

This entire overglaze trend has now reached such a development that the 20th century may justly be called the century of the overglaze as the 19th century is called the century of underglaze.

Stoneware is a material closely related to porcelain, even though in its body it appears harder as well as fuller. It has been artistically utilized since the gray days of antiquity. We have one piece from the 8th century from Corea or Manchuria, and one may, to a certain extent, justly speak of stoneware in the tomb of Tuk-Ammon in Egypt, even though it hardly corresponds exactly to our present-day idea of stoneware.

Stoneware, the material of which so nicely yields to the whims of the artist, offers unlimited possibilities of development and, consequently, greatly appeals to the artist.

Jais Nielsen commanded attention at the Paris exposition, with his powerful compositions. Jais Nielsen is fond of a very powerful material. He mixes his stoneware body with chamotte to make the material still coarser. He covers this material with gray glaze and paints the jars beneath the glaze, especially with a blue color. There is no doubt that Jais Nielsen has decorative talent of the highest rank. Few can, like he, cover the surface of a vase decoratively, bringing out such effects.

But Jais Nielsen is not limited to painting; he is a sculptor as well and has produced the most magnificent things. I may here mention his large, life-size figure, "The Potter," exhibited at the Danish Porcelain Works in Paris. His charming and forceful group "The Good Samaritan," "Samson and the Lion," and the many other works created by him are exceptional. Lately he particularly occupied himself in turquoise-colored effects, as for instance in the great angular vase which on request we have taken the liberty to send to this great meeting.

Alongside with him there is an artist like Knud Kyhn. Knud Kyhn is a sculptor, and he has quite a definite field in which he works and is a master, namely the representation of animals. What he can get out of a monkey, a bear, a cat, a dog, and how he can bring out the life, the sparkle and the force of such animals can only be realized by those who have seen it themselves. I am happy that we have been asked to send examples of his art to this great meeting.

An entirely new artist in this field is the young artist Bode Willumsen, who has in the short time in which he has been connected with the Works (only about two years) already been able to carve a way of his own, and although at his young age he may still be said to be somewhat under the great influences of a large ceramic enterprise such as ours, he is gifted with such initiative, and a fresh and personal feeling, that no doubt the most beautiful works may in future be expected from his hands. His large vase with the quadriga, his llama, and several of his works are so peculiar that they cannot but arouse attention.

From the days of old, the Chinese "Sang de Boeuf" has been known and utilized. The technique adopted for the red stoneware of the Royal Porcelain Works is something similar. It is a copper-glaze giving a red color; but the blue shades and tints so easily appearing in the "Sang de Boeuf" have successfully been avoided, and a charm and fineness of the red color have been reached, which I, at any rate know of nowhere else. The glaze which we call plum-glaze, is of un-

surpassed beauty. Unfortunately, this line is so very limited as only a small fraction of the articles produced are successfully fired, and we are greatly pleased if one or two pieces succeed in an oven.

One of the latest creations is the Celadon porcelain. Celadon was originally a product which appeared more than 1000 years ago in China by an erroneous use of a glaze. This glaze was green, and was developed to a high degree of perfection by the Chinese. Later on, this technique fell into complete oblivion; but the Royal Porcelain Works has resumed it during the last ten years, and in our opinion most successfully. In this line is a ceramic field not sufficiently adopted by art. The Celadon porcelain can be given the appearance of being closely related to minerals like jade, and there is a cool beauty in the material itself and in the color which is highly appealing. The Works expects a good deal from this production. We have taken the liberty to send to the exposition one of these pieces, a vase by Hans Hansen.

Another new creation by the Works is the production of bisque. Bisque is unglazed porcelain which through the very omission of glaze attains to the greatest beauties. For more than 100 years the Works has been making bisque, but of a material far from satisfactory. However, after a series of experiments lasting about ten years a material has been developed which we consider equal to what can possibly be accomplished in this line. In order to give an idea of what we understand by bisque we have taken the liberty to send a single figure by Malinowski, "The Bali Dancer" to the exposition, hoping that the beauty of the right working of the appropriate material will be seen.

On the whole I dare say that our entire work at the Works is based upon the correct use of the various materials. Porcelain and porcelain may be two different things, and if we tried to make under-glaze porcelain and over-glaze porcelain of the same material the world would be most justified in refusing to accept such efforts as evidence of flawless art.

The rule of action which we always make the basis of our work, is that art and the material must be most intimately connected with each other. The same article cannot be made in crockery and in porcelain, nor can the same article be made in tin and in silver. What looks well in one material may look badly in another, and it is the full recognition of this fact, so important to all applied arts, of which we urge the necessity on every occasion, and which is throughout made the basis of the work in our Works.

Crockery is a contrast to porcelain; crockery appears in gay colors, with sparkling life, whereas porcelain is cool and reserved. Porcelain may be compared to a fine noble lady, and crockery to a pretty bourgeois girl, and both always have their admirers.

In closing the mention of the Royal Porcelain Works and its daughter works, the "Københavns Fajancefabrik" ("The Copenhagen Crockery Works"), I beg leave once more to express the heartfelt thanks of the Works and myself for the distinction and honor shown us on this occasion.

THE NEED OF A SCHOOL OF CERAMIC DESIGN IN OHIO[1]

By Henry Turner Bailey

In the development of any product, when once the conditions of use have been met, beauty assumes the place of first importance. The automobile is a good example.

A person of intelligence, when confronted with a need any manufactured object can meet, and offered the opportunity to choose between that object mechanically perfect but ugly, and mechanically perfect but beautiful, can be depended upon to choose the beautiful thing.

Beautiful things do not come by luck nor can they be produced upon demand. They always have come and always must come from craftsmen unusually sensitive to the elements of beauty, proportion, line, color, texture, and organic unity and unusually skilful through long experience in producing excellence in the work of their hands.

In the old days a craft came down in a tribe or family, from generation to generation with cumulative effectiveness. Later it was transmitted through Guilds where membership was acquired only through years of service under the Masters. The apprenticeship system followed, where the aspiring workman was indentured to a single craftsman for a specified period to learn his trade.

All these systems were effective, to a degree, in maintaining high standards and in offering scope to the especially talented.

In our day the hope lies in professional schools, with machinery for discovering among the restless masses of children the specially talented in any realm, and for training each according to his own ability. Children with unusual responsiveness to beauty and the arts are the nation's greatest potential asset. They will produce the architecture, sculpture, painting, decoration, illustration, literature, music, and drama of the future, and all the furniture, household utensils, ornamental accessories, costumes, jewelry, and precious books for the next generations to enjoy.

All the industries in whose product the æsthetic element is a factor, must lead in the recognition of these conditions and in adjustments

[1] Abstract of an address presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927.

to them, if they would lead in profiting by the ever increasing intelligence, taste, and wealth of the public. The public can be depended upon to demand finer products every year and those who can produce such products will win the trade.

The ceramic industries of Ohio offer no exception. Their only hope for increasing prosperity lies in increasing excellence of product. And that can come only from more tasteful and more skilful designers.

These must be discovered early, trained thoroughly in the history of the craft, in the elements of beauty and the principles of design, and in the practice of the ceramic technique, under competent instructors.

Such a program can be realized only when the manufacturers coöperate whole-heartedly with the art educational agencies already established. Only through such coöperation can courses and methods be discovered and perfected to promote the higher commercial interests of the immediate future.

Director of the Cleveland School of Art and of the John Huntington Polytechnic Institute
Cleveland, Ohio

ACTIVITIES OF THE SOCIETY

REPORT OF COMMITTEE ON STANDARDS[1]

American Ceramic Society 1926–27

As the reprints of the *Report of The Committee on Standards 1921–22*, constitute the book of standards of this SOCIETY and as the supply of these reprints is now exhausted, the General Secretary is urging that the present Standards and Tentative Standards be reviewed by this Committee and changes, where necessary, be made and submitted to the SOCIETY for vote before a new book of Standards of the AMERICAN CERAMIC SOCIETY is issued. This your committee has been endeavoring to do.

The records of the SOCIETY show the following:

Tentative Standards Elevated to Regular Standards

(By vote of the SOCIETY since the 1921–22 Report was issued)

(*a*) Method for Sampling Ceramic Materials as Delivered

(*b*) Method for Slaking

(*c*) Standard Scale for Testing Sieves

(*d*) Definitions for Clay Refractories, as Revised by A.S.T.M.

(*e*) Specifications for Limestone, Quick-lime, and Hydrated Lime for Use in the Manufacture of Glass

(*f*) Specifications for Ceramic Whiting

Standards Approved by this Committee and Referred to the Society for Vote

(*g*) Definitions of Clay, Surface Clay, Fire Clay, and Shale

(*h*) U. S. Govt. Master Specifications for Fire Clay, No. 334*a*

(*i*) U. S. Govt. Master Specifications for Plastic Fireclay Refractories, No. 335*a*

(*j*) Test for Resistance of Fireclay Brick to Spalling Action, A.S.T.M., C38–26T

(*k*) Definitions for Plastic or Bond Clay, Flint Fire Clay, Diaspor Clay, and Nodular Fire Clay

(*l*) Pyrometric Cone Equivalent (P.C.E.) definition

Tentative Standards Approved by this Committee

(*m*) Definition of "Spalling" with appended classification of causes of spalling

(*n*) Specifications for Clay Fire Brick (Approved by the American Refractories Institute and A.S.T.M.–C8)

This Committee has secured the coöperation of the Manufacturers Advisory Committee in modifying the "Standards for Vitreous China Plumbing Fixtures" to read "Vitreous China Plumbing Fixtures" instead of "Vitreous China" as was originally proposed. This was necessary because the standards for this ware do not equal the standards for other ceramic ware classed as vitreous.

This Committee is continuing its contact with the Division of Simplified Practice, Department of Commerce and reports valuable work accomplished by that committee on paving brick and vitreous grinding wheels.

Coöperative work with the Nomenclature Committee of C8–A.S.T.M. enables your committee to present tentative definitions for "plastic or bond fire clay," "flint fire clay," "diaspor clay," and "nodular fire clay." A definition for "spalling" is also offered as "tentative" by this joint committee.

The C8 Nomenclature Committee proposes to abandon the terms "fusion," "melting point," and "softening point" in connection with specifications for refractories and introduce a new term "Pyrometric Cone Equivalent" (P.C.E.) for which a tentative

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[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927.

definition is now offered. Your Committee coöperated with the A.S.T.M. Committee and accepts the proposed definition believing it will be satisfactory to all ceramic groups.

Your Committee on Standards has also started coöperative work with the foreign ceramic societies, on the definitions of ceramic terms of international interest, including porcelain, china, etc.

It will not be possible to longer postpone publication of the new edition of Standards of the AMERICAN CERAMIC SOCIETY and your Committee proposes to shortly submit such copy as is available, introducing as tentative that matter which for lack of time is not ready for final vote of the SOCIETY.

Respectfully submitted,

ARTHUR S. WATTS, *Chairman*
H. SPURRIER
STUART M. PHELPS
EMERSON P. POSTE
R. F. GELLER
A. V. HENRY

STANDARDS COMMITTEE REPORT[1]

Approved February 16, 1927 and referred to the General Secretary for vote of the SOCIETY.

1. *U. S. Government Specifications for Fire Clay, No. 334a* (Navy simulated service test omitted)

2. *U. S. Government Specifications for Plastic Fire Clay Refractories—No. 335a.* Revised as per attached copy. (Navy simulated service test omitted)

3. *Test for Resistance of Fireclay Brick to Spalling Action, A.S.T.M.—C–38–26T.*

Definitions

4. *Plastic or Bond Fire Clay.*—A fire clay of sufficient natural plasticity to bond nonplastic materials.

5. *Flint Fire Clay.*—A hard or flintlike fire clay occurring as an unstratified massive rock, practically devoid of natural plasticity and breaking with a concoidal fracture.

6. *Diaspor Clay.*—A rock consisting essentially of diaspor bonded by fire clay.

7. *Nodular Fire Clay.*—A rock containing aluminous and ferruginous nodules bonded by fire clay.

NOTE: In some districts such clays are called "burley" or "burley flint" clay.

8. *Pyrometric Cone Equivalent* (*P.C.E.*).—An index to the degree of fusion resulting in a cone of the material bending until the tip touches the plaque as a result of a definite heat treatment prescribed by the A.S.T.M., Serial Designation C–24–20. The terms "fusion," "softening" and "melting points" have heretofore been loosely used for "pyrometric cone equivalent."

Respectfully submitted,

ARTHUR S. WATTS, *Chairman*
Standards Committee, AMERICAN CERAMIC SOCIETY

SPECIFICATIONS FOR PLASTIC FIRECLAY REFRACTORIES

(U. S. Government Specifications, No. 335*a*, Revised)

I. Material Covered

1. These specifications are intended to cover a refractory fireclay material furnished in a plastic form and particularly adapted to ramming in place, replacing special shapes.

[1] Received April 1, 1927.

It is recommended also for use in the construction of small furnaces such as are used in domestic heating plants, in baking ovens, and in laboratory apparatus.

II. Manufacture

2. The method of manufacture is not covered in these specifications.

III. Grades

3. The material furnished under this specification shall be of one grade only.

IV. Physical Properties and Tests

4. *Silica Content.*—The material shall contain not more than 65 per cent total silica (SiO_2) calculated on the dry weight.

5. *Softening Point.*—The softening point shall be not less than that of Orton pyrometric cone No. 31 (approximately 1680°C or 3056°F).

6. *Water Content.*—The material as delivered shall contain not more than 15% water calculated on the plastic weight.

7. *Shrinkage.*—The total linear dry and fired shrinkage shall not exceed 4% of the plastic length.

V. Methods of Inspection

8. *Sampling.*—A sample of not less than 50 pounds shall be taken from one container, taken at random, for every shipment of one carload or less and shall be so taken as to be truly representative of the material in the container.

9. *Testing.*—(*a*) *Silica content.*—The content of total silica shall be determined by analytical methods described under the A.S.T.M. Standard Method, Serial Designation C18–21.

(*b*) *Softening point.*—The softening point shall be determined according to the A.S.T.M. Standard Method of Test for Softening Point, Serial Designation C24–20.

(*c*) *Water content.*—The water content shall be determined by drying a specimen of not less than 200 g (approximately 7 ounces) to constant weight at a temperature of not less than 110°C and not more than 150°C. The per cent water shall then be determined in accordance with the following formula:

$$\text{Per cent water} = \frac{W - D}{W} \times 100$$

where

W = the weight of the material as received

D = the weight of the material after having been dried to constant weight

(*d*) *Shrinkage.*—The total linear dry and fired shrinkage shall be conducted on brick which have been prepared of the material (as delivered) by hand ramming with a wooden mallet in suitable wooden molds of inside dimensions approximately 2½ by 4½ by 9 inches. The brick shall be removed immediately from the mold and set on edge on a suitable pallet and marked on the 9 by 4½-inch faces with gage marks approximately 8 inches apart. The sample shall then be carefully dried and fired uniformly under no load to 1400°C (2552°F) in not less than five hours and held at this temperature for five hours and allowed to cool in the kiln and without induced draft to room temperature. The distance between gage marks shall be measured to the nearest thirty-second of an inch and the shrinkage calculated in accordance with the following formula:

$$\text{Per cent shrinkage} = \frac{L_w - L_b}{L_w} \times 100$$

where

L_w = length of the specimen in plastic state,

L_b = length of specimen after firing at 1400°C.

The shrinkage of any one specimen shall be reported as the average of the distance between the two sets of gage marks, and results of any one brand shall be reported as the average of five specimens.

VI. Workmanship and Finish

10. The material as finished is essentially dependent upon workmanship at time of installation and therefore requirements for workmanship do not come within the scope of these specifications.

VII. Markings

11. The material shall be packed in containers so constructed as to insure delivery of the material in satisfactory condition. The size and type of the container shall be as specified by the purchaser and each container shall be plainly marked with the trade name of the material, the contract number, and the name of the contractor.

VIII. Inspection and Rejection

12. The consignor shall be notified of the rejection of a shipment based on this specification, unless otherwise specified, within 10 days after receipt of a shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of receipt of said notice.

REPORT OF THE COMMITTEE ON RESEARCH OF THE ENAMEL DIVISION OF THE AMERICAN CERAMIC SOCIETY

1926–1927

The activities of the Research Committee for the past year have consisted almost entirely of the prosecution of the investigation on the relation between the physical and chemical properties of cast irons and their enameling properties.

The experimental work in connection with this investigation is being conducted by the staff of the Bureau of Standards. The following is a progress report relating to this investigation.

Progress Report on Cast Iron for Enameling Purposes

The purpose of this work is to determine the difference between northern and southern pig irons, in respect to their tendency to produce blisters in the enamel applied to them. Once the cause of this difference is known, the way will be open to treat blistering iron in such a way as to produce nonblistering iron.

Organization of the Investigation

This problem has been a source of considerable loss and annoyance to manufacturers of cast iron ware, and the Bureau of Standards, in coöperation with the AMERICAN CERAMIC SOCIETY undertook to investigate it. Within the Bureau three divisions are coöperating. The Ceramic and Metallurgy Divisions are doing the major portion of the work and the Chemistry Division is also involved. As you know, various manufacturers have contributed in some form to the work.

Review of First Efforts

The original plan was for the castings, which are made at the Bureau, to be enameled by six different manufacturers, as well as by the Enamel Section at the Bureau. The specimens which were treated in this way were more susceptible to arrangement according to the manufacturers doing the enameling than according to type of cast iron. Some of the manufacturers were accustomed to enameling any iron that came their way, and were able to make a fairly good job of all the castings, while others who were accus-

tomed to exercising more control over their iron, ran into blistering with some irons. Then, too, some manufacturers used dry process and others wet process and, of course, the blisters were more numerous with the wet process.

These results did not help much toward solving the problem, but they did bring out information of importance. They proved in a manner that nothing else could have equalled, that enameling practice has a tremendous influence on the results obtained and that iron which would be considered unusable in some quarters would be acceptable in others.

It appears that even these results constituted a measurable and valuable step toward accomplishing the end in view, and I believe they have already been profitable for some manufacturers.

Development of Standard Practice

Since the object of the investigation was to study the differences in *cast irons* rather than *enameling practices*, the parties responsible for the investigation decided to entirely change the plan of attack. In accordance with the new plans, a representative of the SOCIETY was sent to the Bureau to coöperate in working out a standard enameling practice for the investigation. Thereafter all castings were to be enameled at the Bureau. The standard practice developed was such that a nonblistering iron would be free from blisters, but if an iron had a tendency to cause blisters it would be brought out. The *wet process* was best adapted for this purpose.

A supply of ground coat and cover coat frits which had been prepared commercially and found to be nonblistering in themselves, was forwarded to the Bureau, and also a lot of nonblistering stove parts against which to check the enamel.

Special Ground

Quartz	13 lbs. 3 ozs.
Borax	7 " 4 "
Soda niter	1 " 4 "
Red lead	1 " 7 "
Boric acid	1 " 3 "

Sinter for one hour at 1550°F to 1600°F in an enameling muffle

Special Cover

Borax	142
Feldspar	203
Quartz	84
Fluorspar	32
Soda ash	32
Potash niter	16
Cryolite	25
Red lead	94
Zinc oxide	41
Whiting	13

Mill Batch

Frit	10 lbs.
Stone	46½ "
Water	5½ "

Grind 12,000 revolutions, then add:

Water	1 lb.
Clay	1½ lbs.

Grind 3,000 revolutions

Coarser than 115-mesh	0.04%
Between 200- and 115-mesh	0.03%

Mill Batch

Frit	10 lbs.
Clay	9.6 ozs.
Tin oxide	1 lb.
Water	4.5 lbs.
Stones	46.5 "

Grind 12,000 revolutions

Coarser than 115-mesh	0.06%
Between 200- and 115-mesh	2.54%

Application

The grinding procedure was standardized according to the grinding equipment available at the Bureau. The slips are adjusted to standard specific gravities and applied in definite weights and thoroughly dried.

Firing The firing is, of course, carried out under definite conditions of time and temperature. Specimens from eight different heats are placed on the rack at one time. In each successive load the same relative position of pieces representing differ-

ent heats is maintained. That is, if the piece from heat 50 occupies the "north east" corner of the rack on one load, it does on all.

Six specimens from each heat are completely enameled, one from each is left with ground coat only as a sample, and one from each kept as an iron sample.

Grading The finished pieces are graded according to an arbitrary scale consisting of five enameled pieces arranged in order of increasing seriousness of blistering. These are number I to V. Grades I and II are commercial, and the others represent different stages between commercial and No. V, which is quite badly blistered. The finished pieces are graded, tied in bundles, and placed on file.

New Method of Casting Specimens

After the development of the standard enameling procedure the method of casting specimens was changed. Up to that time the specimens (3 x 6 x $\frac{3}{16}$ inches) had been cast individually, four at one pouring. The new method is to cast a plate 18 x 18 x $\frac{3}{16}$ inches, which is cut into eighteen 3 x 6-inch specimens, each of which bears a number cast into it so that its position in the plate can be identified. In this way specimens of greater uniformity can be obtained. The majority of them are not next to gates and are, therefore, less apt to contain inclusion of dirt or other defects common to sections of castings which are adjacent to gates.

Use of Various Facings

The lead which is being worked on at this time is the relation between soundness of castings and blistering. Although until recently no facings have been used on any of the molds, it became highly desirable to know what effect the use of different facings would have upon the production of blisters. Accordingly a series of plates was cast from a northern iron, the only variable being the facings used. These were wheat flour, silica flour, ethylene-glycol, silica flour suspended in ethylene glycol, and plumbago respectively.

Tracing Blisters

All castings are sandblasted and inspected before enameling, and careful notation is made as to the character and location of any visible defects. As an aid to the location of a defect, a paper form the same size as the casting is divided into eight squares, which are numbered. A casting might be good except for a single slag hole. If, then, a notation is made "slag hole north east corner square seven," and a blister appears at that spot, it is not charged against the iron. With a less definite means of locating the defect, it would be difficult to do this.

As a matter of interesting experiment we tried placing a sheet of paper over a blistered piece and recording the location of the blisters by scratching a soft pencil back and forth, as you used to get the imprint of the name of a book when you first went to school. The enamel was then sandblasted off of the piece, and the iron immediately under each blister examined. This method has not been extensively developed. About all that can be said is that in the case of several pieces so examined some of the blisters were successfully traced in that way, but a larger number were not.

Status of Work The work on this problem has not yet reached such a stage that definite conclusions can be drawn. Progress has been slow, but we feel that definite progress has been made and that with the new method of casting, the standard enameling practice and method of grading pieces, it seems reasonable to expect more definite results in the near future.

HOMER F. STALEY
CHAIRMAN, COMMITTEE ON RESEARCH

REPORT OF THE CHAIRMAN OF THE REFRACTORIES DIVISION TO THE GENERAL SECRETARY OF THE AMERICAN CERAMIC SOCIETY

(March 1, 1926–Feb. 1, 1927)

The outstanding activity of the Division has been centered in the publication of a *Bibliography on Refractories.*

The question of by-laws for the Division was given considerable thought and a definite recommendation has been prepared. In accordance with the suggested by-laws we endeavored to have officers for the coming year nominated in sufficient time to permit the publication of their names in the February issue of the *Journal.* In this way their election at the Annual Meeting would be a proceeding having some semblance of formality since it could be assumed that those voting had had time to consider the qualifications of the nominees.

We have also endeavored to obtain abstracts of papers, listed for reading at the annual meeting, in time to have them available in printed form for those attending the Division sessions. The Chairman of the Program Committee was quite successful in this respect; it is to be hoped that those attending will avail themselves of the service and prepare written or mental discussion.

If the discussions are forthcoming it is probable, according to past experience, that the time available would not permit giving them due consideration. Accordingly an innovation was suggested, the success of which remains to be seen. It is intended that the time of presentation of papers and their tentative discussion shall be strictly limited to 10 and 5 minutes respectively. If the tentative discussion indicates that points in the paper have aroused an active discussion, it will be noted and the paper again taken up at a Round Table to be held on the last half day of the "technical" meeting. This Round Table should be strictly informal, the members being given the opportunity to call on those who delivered the papers for any additional points of interest which could not be taken up in detail at the first reading. In this way *every one* will be given the opportunity to read his paper and those papers of especial interest can be discussed at length during the Round Table without working a hardship on any one.

The bulk of the Division work was, naturally, carried on by its various committees and the reports of the chairmen are hereby submitted:

Committee on Research

(M. F. Beecher, *Chairman*)

"There being no precedents established or work outlined or proposed, left over from former committees, it was necessary first of all to consider what we could do to further research on refractories and how we should proceed.

"Obviously the Committee could not be expected to carry on research of and by itself, hence assistance in furthering research must be given by:

(*a*) Surveying the needs of the industry and selecting the problem (or problems) in most need of solution, and attempting to interest some University, State, or Federal laboratory in carrying out the fundamental studies necessary to its solution, or:
(*b*) To assist these same laboratories in the prosecution of researches already under way, by obtaining materials for their use, arranging for criticism of work, and by offering suggestions for improvement in outline of procedure.

"The Committee feels that in none of these laboratories is there any dearth of problems, and that suggesting additional ones would be neither helpful nor worth while. It is probable, however, that some help could be given as outlined under item (*b*) above.

"It is, therefore, proposed that each of the University, State, and Federal laboratories be informed by letter that the Committee will be glad to assist them in their ceramic research by:

1. Lending their aid in procuring materials required for test or experiment
2. Obtaining competent criticism
3. Getting suggestions for improvement of experimental procedure from able and authoritative sources

"It is not expected that the committee will be deluged by requests. If, however, it can assist one laboratory in the prosecution of a single research study during the next year, it will feel amply repaid."

Standards Committee on Tests

(S. M. Phelps)

No formal report was submitted, but the present A. S. T. M. spalling test was presented, for consideration by the main Standards Committee, as a tentative standard of the SOCIETY.

Standard Committee on Products

(J. S. McDowell, *Chairman*)

No report submitted.

Committee on Data

(C. W. Parmelee, *Chairman*)

No report submitted.

Committee on Membership

(S. S. Cole, *Chairman*)

"The Membership Committee has, during the past year, attempted to check the addresses of the members of the Division, and make corrections as to membership in the Division.

"The Division as compared with the year 1925, has shown an increase.

	1925	1926
Members (active)	328	380
Corporation members	40	47
Members dropped from SOCIETY or changed to another Division	—	22
Total	368	405

"Of the corporation members, 30 are producers of refractories and the remainder are makers of abrasives, plastic fire clay, etc. This represents about 20% of the total firebrick manufacturers in this country and from that figure, it seems quite probable that all the manufacturers are represented in the Division either by corporation membership or individual membership. I believe that it is not possible to increase the membership of this Division appreciably since all individuals interested in refractories are now connected with the Division.

"A field which has not been pressed very strongly is the iron and steel industry. There are no doubt many consumers there who are not represented and this might be a possible field for the succeeding Chairman of the Membership Committee."

Committee on Rules

(D. W. Ross, *Chairman*)

This committee has been very active during the past year and prepared:

1. Recommended by-laws for the Division, a copy of which is appended.
2. Recommended by-laws for all Divisions—these were submitted directly to the General Secretary's office.

Committee on Education

(A. S. Watts, *Chairman*)

Professor Watts's report is as follows:

"This subject has resolved itself into a general round-table discussion and every one interested is being urged to express himself. A general conference on this subject has been planned for the February meeting of the SOCIETY.

"All this should provide the Committee of our Division with a suitable background for constructive work. I do not believe that it would be wise for any individual division of the SOCIETY to undertake a recommendation in the face of the very general discussion which is now under way.

"If you believe this Committee should attempt to prepare definite recommendations, please so advise me and I will see what can be done."

Committee on Nominations

(F. A. Harvey, *Chairman*)

No report available on Feb. 1.

Committee on Cooperation

(L. C. Hewitt, *Chairman*)

The activities of this Committee have been practically confined to coöperation with the American Foundrymen's Association in the matter of refractories for that industry, and Mr. Hewitt is general chairman of this very important Committee on which the following groups are represented:

AMERICAN CERAMIC SOCIETY
American Foundrymen's Association
American Refractories Institute
American Malleable Castings Association
American Society for Testing Materials
American Electrochemical Society
U. S. Bureau of Standards
U. S. Bureau of Mines
U. S. Department of Commerce, Division of Simplified Practice
Steel Founders' Society of America
Electric Steel Founders' Research Group
Institute of Metals Division, A. I. M. E.

Their subcommittee on Survey has completed preliminary reports relating to the steel castings, and malleable and nonferrous industries; their subcommittee on Tests and Specifications prepared a tentative specification for refractories used in malleable-iron furnaces; and their subcommittee on Standardization and Simplification concentrated on the standardization of sleeves and nozzles.

Committee on Papers and Programs

(E. H. Van Schoick, *Chairman*)

No formal report was submitted. It is thought the program of papers for the 1927 meeting speaks for itself.

One recommendation which I should like to leave with the Secretary concerns the papers published in the *Journal*. The *Journal* now undoubtedly contains the foremost publications of ceramic technical and scientific research in the United States. A reputation has been gained which can not be guarded too jealously. Therefore, I would like to recommend that the SOCIETY, through its general officers and trustees, devise an active and effective editorial board to pass on all papers submitted for publication. This Board should not be held responsible for the language in which the report is couched, but would be accountable for the accuracy and significance of the methods used and the conclusions reached; also, in cases of controversy involving previous papers, this Board should see that the author of the paper criticised be given an opportunity to review the criticism before publication and to submit an answer if he so desired.

R. F. GELLER, *Chairman*,
REFRACTORIES DIVISION FEB. 1st, 1927.

By-Laws of the Refractories Division

1. Purpose The objects of this Division shall be the same as those of the parent SOCIETY but shall be specific to refractories.

2. Membership The membership shall consist of members of the AMERICAN CERAMIC SOCIETY, who shall designate their desire in writing to the General Secretary of the Society to be so registered.

3. Officers The officers of the Division shall consist of a chairman, a vice chairman, and a secretary who shall perform the duties ordinarily pertaining to these offices. The officers together with the chairman of the Program Committee shall constitute an Executive Committee which shall manage the affairs of the Division. The officers shall be elected annually by acclamation or, in case of doubt, by ballot at the first day's session of the Division held during the annual meeting of the SOCIETY and shall take office at the close of the meeting at which they are elected. The Chairman shall not be eligible for immediate re-election. Any vacancies occurring during the year shall be filled by appointment by the Executive Committee. A person so appointed shall not forfeit the privilege of election to the same office to succeed himself.

4. Elections **(a) Division Officers**—The Chairman shall appoint a nominating committee consisting of three members, no two of which shall be from the same branch of the Refractories Industry, that shall nominate one candidate for each divisional office. They shall report their nominations to the Division Executive Committee in time so that the Division Secretary can have the nominations advertised in the *Bulletin of the American Ceramic Society* at least once before the Annual Meeting.

Any five members of the Refractories division may place an additional name or slate of names in nomination by designating such nominations to the Division Chairman in writing, signed by themselves as seconders, at any time before the actual voting for the office designated begins.

(b) General Nominating Committee.—The Chairman of the Nominating Committee shall be the Refractories Division's representative on the general nominating committee of the SOCIETY.

(c) Trustee.—At least ninety days preceeding the Annual Meeting at which the Trustee from the Refractories Division is to be elected, the Division Secretary shall submit nominating ballots to the members of the Division who shall designate two names as their preference for this office. The three highest names on the nominating ballots returned within thirty (30) days shall be placed on a ballot and submitted to members of the Refractories Division. The person receiving the highest number of votes within thirty (30) days after ballots being sent out shall be declared elected.

5. Meetings The Division shall meet in conjunction with the Annual Meeting of the parent SOCIETY and at such other times and places as the Executive Committee acting with the General Secretary of the SOCIETY shall decide.

6. Standing Committees **(a)** The Division Chairman shall appoint a Division Program Committee.

(b) The Division Chairman shall appoint a representative of the Refractories Division to serve on each of the following committees of the AMERICAN CERAMIC SOCIETY:

Group on Standardization of Tests—one representative
Group on Standardization of Products—one representative
Committee on Research—one representative
Committee on Data—one representative
Committee on Membership—one representative

Any one of these committees may be dropped and new committees be added by action of the Executive Committee in accordance with the requirements of the parent SOCIETY.

7. Special Committees The Chairman of the Division shall appoint such committees as the Executive Committee may deem necessary.

8. Rules Governing the Presentation of Papers So that special programs can be arranged, details concerning the order and time of presentation of papers may be determined by the Executive Committee for any period prior to the start of that period. However if the Executive Committee does not prearrange such matters the procedure shall be as follows:

(a) The time allowed for the presentation of any paper before any meeting of this Division shall be limited to twenty minutes unless otherwise ordered by vote of the members present.

(b) The time allowed for the discussion of any paper shall be five minutes per speaker, however any person speaking on a paper may speak again after all others desiring to speak on the paper have been heard. If occasion arises the total time of discussion of any paper may be limited by vote of the members present.

(c) Papers containing promotional or advertising material shall not be presented. The Chairman of the Program Committee shall approve papers. In case of argument resulting from disapproval, or in case of doubt, final decision shall rest with the Executive Committee.

(d) The publication rights of all papers and written discussion presented before the Division shall be vested in the AMERICAN CERAMIC SOCIETY unless such rights are specifically released in writing by the General Secretary of the SOCIETY.

9. Amending the By-Laws These By-Laws may be amended in the same manner as the By-Laws of the parent SOCIETY are amended.

10. Quorum Ten per cent of the membership of the Division shall constitute a quorum. A majority shall rule except as otherwise specified in the By-Laws.

VARIETIES OF PAVING BRICK INCREASED

The Permanent Committee on Simplification of Varieties and Standards of Paving Brick met in Washington on March 31, 1927.

O. W. Renkert, AMERICAN CERAMIC SOCIETY representative on this Committee, attended the meeting and presented the following report.

The Standard Varieties were increased from four types to five types, which are as follows:

Recognized Types and Sizes	Width	Depth	Length
Plain wire-cut brick (Vertical fiber lugless)	4	3	8½
" " " " " " "	4	3½	8½
Wire-cut lug brick (Dunn)	3½	4	8½
Repressed lug brick	3½	4	8½
Added Type			
Plain wire-cut brick (Vertical fiber lugless)	4	2½	8½

The additional type was adopted by unanimous action of the Committee and statistics showed that last year 14.1% of the industry's shipments were of this type.

NEW MEMBERS RECEIVED FROM MARCH 16 TO APRIL 15

CORPORATION

Wheeling Steel Corp., Portsmouth, Ohio. Carl Burkhalter, representative.

PERSONAL

J. I. Boxström, Boulevardsg. 1, Helsingfors, Finland. Metallurgical Engineer.
Edward W. Campion, Asst. Supt., Buckeye Steel Castings Co., Columbus, Ohio.
Chester E. Grigsby, Research Engineer, Evens and Howard Firebrick Co., St. Louis, Mo.

J. Henry Hall, 765 E. 3rd St., Lexington, Ky. Mgr. and Treas. of Whitesburg Coal Co. and Stanton Brick Co.
Edgar Mueller, 1436 Macklind Ave., St. Louis, Mo.
E. T. Orlow, Technological Institute, Charkow, Russia, U.S.S.R.
S. A. Ratajczak, President, Ukrfarfor Trust, Kiev, U.S.S.R.
James W. Ryan, 62nd and Green St., Emeryville, Calif.
M. J. Scammell, Treasurer, Scammell China Co., Trenton, N. J.
George T. Thaler, Bureau of Standards, Washington, D. C.
J. B. Zeldes, Engineer, Ukrfarfor Trust, Kiev, U.S.S.R.

STUDENT

Kuang Chang, 1305 W. University Ave., Urbana, Ill.
D. B. Hall, 103 Harrison Ave., Raleigh, N. C.
Victor F. Houser, 1211 W. Main St., Urbana, Ill.
W. H. Henson, 909 S. 1st St., Champaign, Ill.
Otto T. Kauffmann, Jr., Niedersedlitz, Sa., Germany.
R. Melville Pearce, 2259 N. High St., Columbus, Ohio
Burton E. Peck, 176–15th Ave., Columbus, Ohio
Donovan J. Rice, 1919 Indianola, Ave., Columbus, Ohio
Irvin Schoeninger, 905 S. First St., Champaign, Ill.

Membership Workers' Record

	PERSONAL		PERSONAL
P. P. Budnikoff	1	R. K. Hursh	1
Benjamin Frosterus	1	J. P. Nikonow	2
W. N. Harrison	1	Office	4
B. Mifflin Hood	1		—
	—	Total	11

CORPORATION

Office	1

	STUDENT		STUDENT
A. T. Andrews	1	R. K. Hursh	2
G. A. Bole	1	T. W. Talwalkar	1
A. F. Greaves-Walker	1	Office	3
			—
		Total	9
			—
		Grand Total	21

LOCAL SECTION NOTES

Mateer Addresses Pittsburgh Section on Electrical Porcelain

J. E. Mateer, Section Engineer in charge of Solid Insulation, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., addressed the Pittsburgh Section, AMERICAN CERAMIC SOCIETY, on the subject—"The Application of Porcelain to Electrical Apparatus."

The meeting convened Tuesday evening in the Fellows Room, Mellon Institute of Industrial Research at 8:15 P.M., April 19, 1927.

Mr. Mateer, an authority on electrical porcelain, described the application and technical requirements of the products with respect to both the producer and user. This meeting was of especial interest to both ceramic and electrical engineers.

Pittsburgh Section Meets with American Chemical Society

According to the annual custom a joint meeting of the Pittsburgh Sections of the American Chemical Society and AMERICAN CERAMIC SOCIETY was held Thursday evening March 17, 1927 at the Pittsburgh Station, U. S. Bureau of Mines.

After a dinner and an hour of industrial motion pictures, two interesting papers were given by Stuart M. Phelps, Director of Research and Tests, American Refractories Institute and E. J. Casselman, Industrial Fellow, Mellon Institute of Industrial Research, respectively on "Recent Developments in Refractories Technology" and "Refractories in the Glass Industry."

Mr. Phelps, who is an authority on refractories, described new refractory products, innovations in manufacturing, and testing procedures in the light of the technical requirements of both the producer and the user of refractories. He especially emphasized the chemical composition of refractory raw products, the factors of destruction of refractories, and the requirements for satisfactory service.

Mr. Casselman, an expert on glass-factory refractories, dealt with the types of heat-resisting materials used in glass-making, how they are employed, their defects, and what research has done and is trying to accomplish in improving them. Permeability of various refractories to glasses was stressed as an important factor in their ultimate service.

NOTES AND NEWS

ART MEDALS PRESENTED

Among medals presented by the Architectural League of New York at its Annual Exhibition in February of this year were: Medal of honor in design and craftsmanship in native industrial art was given to Hunt Diederich for two glazed plaques; the Michael Friedsam medal awarded to Frederich Carder of Corning, N. Y., for his contribution to the development of art in industry.

Both Mr. Carder and Mr. Diederich had representative pieces in the exhibition of the Art Division, AMERICAN CERAMIC SOCIETY, at Detroit last February.

$17,500 TO IMPROVE ARC WELDING

The American Society of Mechanical Engineers has accepted the custody of $17,500 given by the Lincoln Electric Company of Cleveland, Ohio, whose sincere desire is to improve the art of arc welding and to indicate the advantages and economies to be gained by its use. A Committee of judges appointed by the Society will pass upon the relative merits of the three best papers presented under the rules of the competition, which may be obtained from the Lincoln Electric Company. For the best paper $10,000 will be given; for the next best $5,000; for the third best $2,500.

MOTION PICTURE DESCRIBES CARBORUNDUM

The Refractory Division of The Carborundum Company at Perth Amboy, N. J. announces the completion of a motion picture production which tells the story of the manufacture of, and uses for Carborundum refractories.

The film begins the story with a most interesting episode showing E. G. Acheson reproducing his original experiment in which the first Carborundum—which is the basis of all Carborundum refractories—was created. The film then shows how Carborundum is produced today in the giant electric furnaces at Niagara Falls, and then the audience is taken to the big refractory plant at Perth Amboy and is shown in detail the various processes of manufacturing Carborundum refractory products.

The second section of the film gives a very instructive and entertaining insight to the uses of these materials in many industries. These views were taken in many prominent plants throughout the country.

The film is now available, and can be secured by applying to The Carborundum Company, Refractory Division, Perth Amboy, N. J. Arrangements can be made for a speaker to present the film, and to supplement the film story with added information on the refractory problem in general.

The Carborundum Company will welcome the opportunity of presenting this film story to any interested groups of organizations.

NOTES FROM THE BUREAU OF STANDARDS[1]

Standard Samples

The U. S. Bureau of Standards has recently prepared standard samples of bauxite, feldspar, fired Refractories containing 40, 60, and 70% Al_2O_3, and soda-lime Glass. These are issued with certificates containing complete analyses and cost $2.00 per sample of approximately 60 g. Samples may be paid for in advance with order or be sent by parcel post C.O.D. in the U. S. and its possessions. All foreign shipments require prepayment together with 20 cents postage for every 300 g. of sample.

A complete list of the Bureau's Standard Samples together with analyses and fees, is given in the Department of Commerce Supplement to Circular No. 25 which can be obtained free of charge upon application to the Bureau of Standards, Washington, D. C.

Laboratories Equipped to Make Thermal Expansion Tests

The Bureau is preparing a list of laboratories equipped for making thermal expansion tests. In order to make this list as complete as possible, it is requested that laboratories in position to make tests for the public advise the Bureau at an early date giving the following information, marking their replies "Attention of Thermal Expansion Laboratory:"

1. Type of equipment used
2. Type of material acceptable
3. Dimensions of specimens required
4. Temperature range covered
5. Accuracy of determinations
6. Free schedule for representative tests

The steady increase in requests for expansion tests at the Bureau has increased the delay which necessarily occurs before a given test can be carried out and has made it impossible for the Bureau to devote as much time as it should to researches in expansivity.

It is thought that many types of expansion tests can be carried out with sufficient accuracy by commercial laboratories and laboratories of educational institutions, thus permitting the Bureau to complete more promptly such tests as are necessarily submitted to it, and at the same time to devote more time to research and development in the field of thermal expansivity.

Directory of Laboratories and Certification Plan

In accordance with the law, the National Bureau of Standards makes tests and carries out investigations for other Government departments. Because of the large amount of this official work it is impracticable for the Bureau to make tests for private individuals if other laboratories can do the work. To inform interested persons of the location of other laboratories, and in anticipation of a marked increase in the demand for independent testing service in both domestic and export trade, the Bureau has compiled a directory of the 207 commercial testing laboratories throughout the country, together with indications of the types of commodities which they are prepared to test. Special

[1] Bureau of Standards, *Tech. News Bull.*, No. 119, March 1927.

care has been exercised to make this list complete. To accompany the list of testing laboratories there has also been compiled a list of the laboratories of 141 colleges which are used not only for the purposes of instruction but also to a considerable extent for research work. In fact, many important industrial research problems are being solved in the college laboratories. The directory has been sent to the printer, and will be available as a regular publication of the Bureau.

The existence of a thoroughly classified list of testing laboratories will have a number of beneficial effects in promoting the use of specifications, not the least important of which will be the inducement offered to the large number of purchasers who have hitherto hesitated to buy on specifications because of their inability to determine whether or not commodities delivered correspond to the specification requirements.

For the purpose of minimizing the disadvantages incident to the use of specifications, the Bureau has inaugurated a so-called "certification plan" in accordance with which there are compiled lists of manufacturers who have expressed their desire to supply material complying with certain selected nationally recognized specifications and willing to certify to the purchaser upon request that the material thus supplied is guaranteed to meet the requirements and tests of the specifications. This plan has already been applied to 48 United States Government master specifications. Copies of any of the 48 lists of manufacturers, to which additions are being made from time to time, can be obtained upon request.

Science and Local Industries[1]

"Science and Local Industries" was the title of the Presidential address delivered by A. T. Green, to the members of the Stoke-on-Trent Association of Engineers. In the course of the address Mr. Green said:

There is a concensus of opinion at the present time, that science is essential to industry. The shrewd industrial expert is the man who can apply the maximum amount of invention and scientific data with the minimum revolution of existing practice. Professor Barr says, "Only those who have a full knowledge of the complex adjustments of production, distribution and utilization of commercial products can realize how great an overturn may result from what appears to be a trifling change in a product that is already in general use."

The Clay Industries

Referring in particular to the application of science to the clay industries, Mr. Green remarked:

The term clay industries is a comprehensive one, including as it does, the production and distribution of wares ranging from the most delicate porcelain to common brick. Yet there are many problems which are common to all the different branches and which must, sooner or later, form the subject of fundamental scientific research in clay technology. Clay, the basis of these industries, is a variable substance, both in ultimate composition and physical properties. Modern research has given prominence however to the existence of an essential "clay substance," a substance which undergoes changes during the firing of the ware. The changes are the subject of much modern research, physical and chemical methods, including the use of the microscope and X-rays, being adopted. From the very complexity of the subject one can anticipate great controversy on the matter. However, the results of experimentation are proving of exceptional value to the industry. Thus, the fact of the formation of a crystalline compound forming a network of an acicular nature, in porcelain and in certain well-fired firebricks, by reason of high-temperature firing, is of definite importance to a consideration of the properties of the finished wares.

Perhaps the chief property of a raw clay mixture is its plasticity. With our present state of knowledge it is impossible to understand the mechanism of plasticity. A test

[1] Presidential address to Stoke-on-Trent Engineers, *Staffordshire Sentinel*, Oct. 19, 1926.

which would measure plasticity, even under very limited conditions, would be a boon to the ceramic industries. Of course, there are tests, which purport to give indications of this combination of properties, based on considerations of the strength of the dried clay material or its extrusion in the working state or the colloid properties of a slip, but at present there is nothing which can be categorized as fundamental.

Firing of Clay Ware

The firing of clay ware is a peculiarly intricate and many-sided question. With the abnormal growth in the technique of combustion, the evolution of the modern kilns, both of the continuous and the tunnel varieties, follows directly from the application of such new knowledge. In fact, fuel economy is such a luminous topic of technical discussion that there is, in the ceramic industry, an almost pathetically haphazard pandering to the reduction of fuel costs. All clay technologists will admit that economy in this direction is of supreme importance to the well-being of the industry, but many are afraid that a considerable number of the methods adopted have not in them a true appreciation of the divergency of the issues involved. Such innovations are often the results of inadequate thinking.

In order to fire any clay ware, a full knowledge of the chemical and physical changes taking place in the material, by reason of the increased temperature, together with the influence of the kiln atmosphere on the ware, is first essential. Truly, there is little fundamental knowledge of these changes available, but there is quite an amount of empirical data, the result both of experience and limited experimentation. With a knowledge of the changes taking place, an appreciation of the time necessary to effect them in the most complete manner should be obtained. This time factor must vary considerably with different clay wares; even in the case of very similar products there may be an appreciable difference. Theoretically, the study of this time factor has hardly received any attention, and this accounts for the intense surprise of many manufacturers when they realize that the firing time for their particular products has been reduced to a very considerable degree by the use of other firing systems. A complete study of the principles appertaining to the time factors involved in the various changes in clay goods would well pay the pottery industries. With the basis of this "time-factor" data, the design of a kiln, particularly of the tunnel variety, can be considered, because such knowledge determines the rate of rise of temperature which must be used, after the allowance of a "factor of safety" based on experience, in the firing of the goods.

Concerning Kilns

The kiln atmosphere can affect both the time of firing and the quality of the finished ware. A theoretical determination of the correct atmosphere throughout the firing must next be considered, and the firing unit should be amenable to the easy control of these variations in the atmosphere. This is a particularly complex matter, and a compromise is all that can be hoped for. Nevertheless, such a consideration is of vital importance, which fact is illustrated by the influence of sulphurous gases on earthenware, *i.e.*, "feathering," by the influence of reducing gases on the color of ceramic products, and many other like phenomena. When the capacity and like features of the kiln are defined, the design can proceed on the basis of the aforementioned knowledge, together with as strict an adherence to the requirements of fuel economy as the essential firing conditions will allow. In this phase of the technique there is great scope both for original laboratory research and practical application.

In connection with the construction of kilns on the soundest scientific principles, there is a tremendous field of research work which still requires to be explored. In the first place, there is the whole physics of the flow of hot gases in a furnace. These gases give rise to the major heating effects, particularly at temperatures below 1100°C. Thus a definition both of the flow and the heating effect would be of inestimable benefit to the industry. Again, the study of the heat transmitting properties of kiln construction material shows that the heat insulation of the walls is worthy of every thought. This project, however, is by no means simple, since the duration of the firing operation has to be considered besides the saving of fuel. Here there is room for experiment on a works scale. Many combustion problems have still to be explored, and only when a solution to these has been affected can the full economy in gas, oil, and powdered fuel firing be obtained.

The foregoing remark may serve to introduce a few of the issues at stake in modern clay technology. These include (1) studies of the fineness of particles and the influence of this fineness on the properties of the fired ware; (2) investigations of the nature of casting

slips and the faults which are common to cast bodies; (3) the mechanism of the drying of clay ware; (4) the properties of plaster of Paris in their relation to the casting operation; (5) the properties of glazes and bodies in their relation to such faults as crazing, peeling, etc. The problems of the clay industry are innumerable and remarkably interesting. The industry is quite amenable to technical control, and is worthy of the most acute scientific investigation. Its technology is, at present, in its infancy. It may seem to an outsider that the clay industry is conservative to the point of retrogression. Nevertheless, the vitality, imagination, and appreciation of technical control, which characterize the more enlightened firms of our staple industry prove that the district's insularity and seeming conservation has been definitely overcome.

SOCIETY OF GLASS TECHNOLOGY

A meeting of the Society of Glass Technology was held in the University, Birmingham, March 16, 1927. Herbert Webb presided. Two papers were presented.

(*a*) **Some Further Developments in Recuperative Glass Furnaces,** by Th. Teisen. A new design of recuperator was described in which there was an increase in efficiency for two reasons: (1) The greater heating surface insured a higher temperature of the secondary air, (2) The reduction in space resulted in smaller radiation and convection losses. The recuperator comprised a main tube of special design combining the features essential for efficiency, and certain auxiliary shapes which together with the tube were required for building up a unit.

With the development of the recuperative furnace there had been a demand for large units. When built on the 2-recuperator principle the design outlined had certain drawbacks. A new design was developed, the "Tetra" recuperative principle, to overcome this. This design had 4 recuperators instead of 2, arranged symmetrically in each corner of the base, and, for large furnaces, afforded the following advantages compared with the 2-recuperator principle: (1) short length of recuperator enabling it to be cleaned or repaired from the front in its full length, (2) more efficient waste heat recovery, (3) in case of repair or cleaning, one recuperator could be shut off altogether and the furnace kept going with the remaining three, (4) the waste gas collecting flues and the glass pits could be arranged (nearly) symmetrically in relation to each other. For very large types, provision had been made to divide the side pockets into two, so as to make each recuperator of a pair absolutely independent of each other. The author also described a simple application of a patent system of oil firing. All new pot furnaces were designed with a view to being fired on this system in case of emergency, as it entailed only slight modification of the design of the pocket. Furnaces working on this system could be fired either with oil alone, or with coal or producer gas in the ordinary way, combined with oil as auxiliary fuel.

(*b*) **The Properties of Some Soda-Lead Oxide Glasses,** by Violet Dimbleby, S. English, W. E. S. Turner, and F. Winks. Prof. Turner in presenting this paper observed that although potash was more often used than soda in these glasses, nevertheless the properties of one kind had a bearing on the properties of the other. The investigations made were systematic, and aimed at the determination of the effect which was produced by increasing progressively the proportion of lead oxide at the expense of the soda. In this way it was found that successive replacement of soda by lead oxide gave glasses with progressively decreasing annealing temperature and thermal expansion. Comparision was also made with glasses containing barium oxide, which were of much commercial interest. The action of boiling water on the glasses was investigated and the percentage loss in weight determined. It was found that lead-oxide glasses were better than those containing lime, while those containing barium oxide were the worst of the series. A new set of factors was determined by which the thermal expansion of lead oxide and barium oxide glasses could be calculated. The new data were valuable for reference

purposes on the scientific side, as well as for industrial practice. The factors originally proposed by Winkelmann and Schott in 1895 had been found to need revision, and the following were the new values: SiO_2 0.15; ZnO 0.21; Al_2O_3 0.52; ZrO_2 0.69; MgO 1.35; PbO 3.18; CaO 4.89; BaO 5.2; Na_2O 12.69; K_2O 11.7.

OHIO CERAMIC INDUSTRIES ASSOCIATION

Spring Meeting

The Ohio Ceramic Industries Association will hold their Spring meeting at Lord Hall, Ohio State University, Columbus, Ohio, Thursday and Friday, May 26 and 27.

The main keynote of the technical session (Friday morning) will be plant and mining efficiency. At that time a report will be made on the mining phase of the state survey of heavy clay products plants.

For the technical session the membership will be divided up into whiteware and heavy clay products divisions.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY

Annual Meeting	Feb. 5–11, 1928	Atlantic City, N. J.
Amer. Foundrymen's Association	June 6–9, 1927	Chicago, Ill.
Amer. Gas. Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Chem. Engrs.	June 1–4, 1927	Cleveland, Ohio
Amer. Refractories Institute	May 18–19, 1927	Atlantic City, N. J.
Amer. Soc. Mech. Engrs.	May 23–26, 1927	White Sulphur Springs, W. Va.
Amer. Soc. Steel Treating	Sept. 19–23, 1927	Detroit, Mich.
Amer. Soc. Testing Material	June 20–24, 1927	French Lick, Ind.
Assn. Chem. Equipment Mfrs.	Sept., 1927	New York City
Exposition of Chem. Industries	Sept. 26–Oct. 1, 1927	New York City
Mfg. Chemists Assn.	June 2, 1927	New York City
Natl. Assn. of Stove Mfrs.	May 11–12, 1927	New York City
Natl. Safety Council	Sept. 26–30, 1927	Chicago, Ill.
Natural Gas. Assn. of Amer.	May 17–19, 1927	Cincinnati, Ohio
Stained Glass Assn. Amer.	June 27, 1927	St. Louis, Mo.

Publications of the American Ceramic Society Wanted

$5.00 per copy will be paid for second-hand volumes of the Transactions of the American Ceramic Society

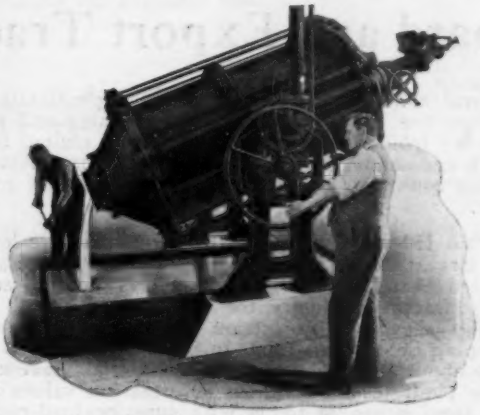
Volumes 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 18, and 19 are out of print.

60c per copy will be paid for each copy of the following *Journals* which are out of print

January, 1924
February, 1924
January, 1925
January, 1926
March, 1926

U. S. Rotary Enamel Smelting Furnaces Give

SATISFACTION



Excellent Results Best Demonstrated by Large Number of Repeat Orders

Crane Enamelware Company, Chattanooga, Tennessee.
Kohler Company, Kohler, Wisconsin.
Porcelain Enamel & Mfg. Company, Baltimore, Md.
Ingram-Richardson Mfg. Company, Frankfort, Ind.
Ingram-Richardson Mfg. Company, Beaver Falls, Pa.
Ingram-Richardson Corporation, Bayonne, N. J.
Grand Rapids Refrigerator Co., Grand Rapids, Mich.
Columbian Enameling & Stamping Co., Terre Haute, Ind.
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B

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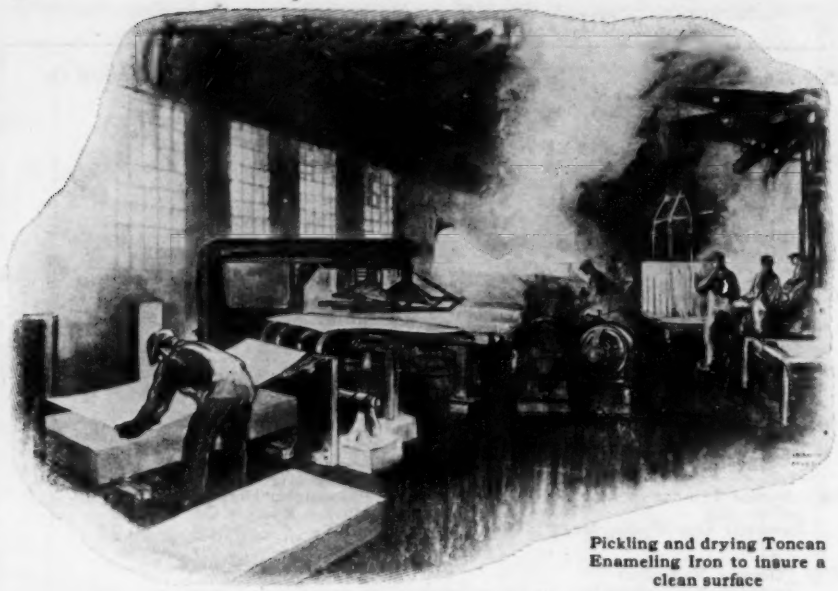

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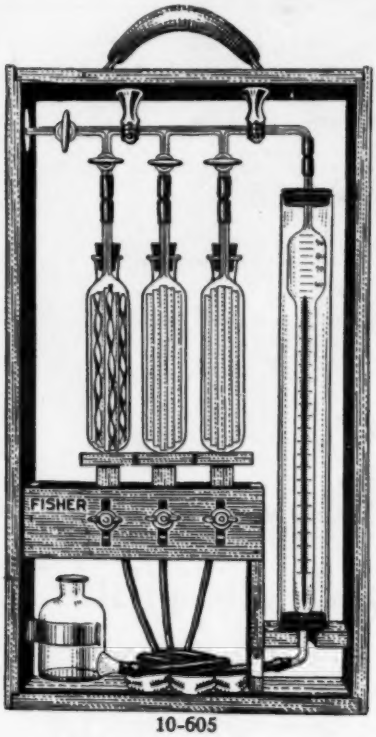

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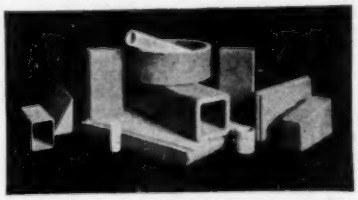

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NORTON REFRACTORIES

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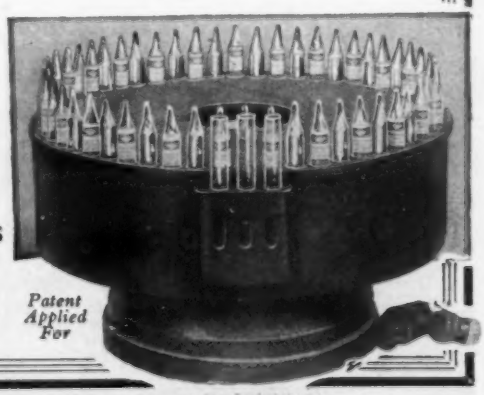

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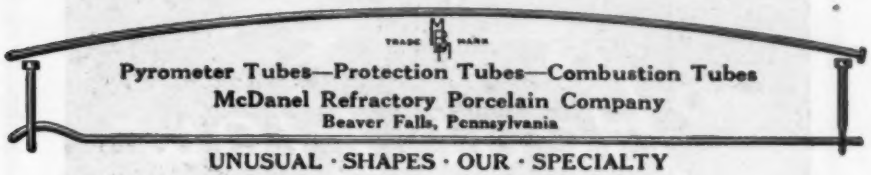

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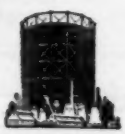

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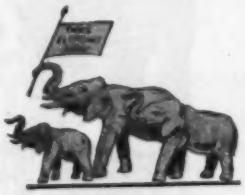

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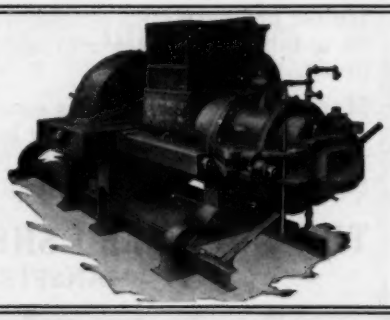

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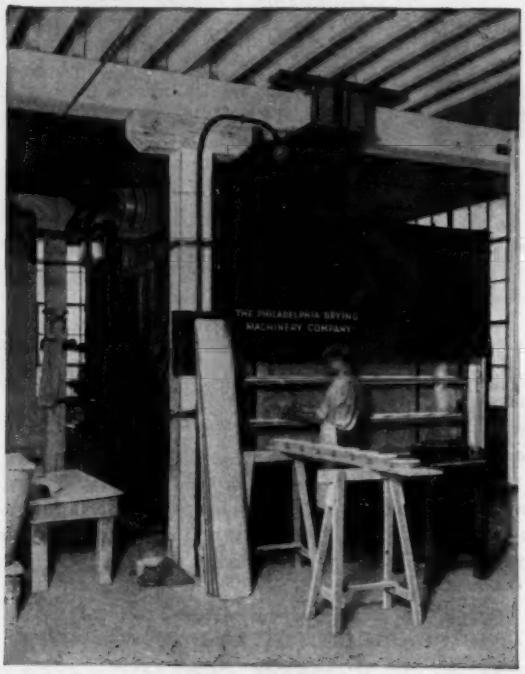

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[illegible] one of the greatest problems [illegible] modern consumer, the Porcelain Lady [illegible] announces the new ultra porcelain offer you [illegible] and can now obtain porcelain that match [illegible] in color tones.

Not only are they free [illegible] color blemishes, but [illegible] enamels, because of their [illegible] finish will [illegible] less net liquid cost and is [illegible] to [illegible] [illegible] than the ordinary enamels.

In every respect equal to the [illegible] Standard, these enamels cover well, [illegible] to [illegible] dissolve, [illegible] a [illegible] compound and one [illegible] coat [illegible] can alone will save [illegible] much as [illegible] per [illegible] cost.

[illegible] considering over your present [illegible] some [illegible] and send for [illegible] [illegible] of one [illegible] gallon.

[illegible] satisfactory to you in every way, you may [illegible] unused portion and receive credit in full, excluding freight charges.

Twentieth Century Enamel

The Porcelain Enamel & Mfg. Company

Baltimore, Maryland

Warehouses, Detroit, Mich., and St. Louis, Mo.